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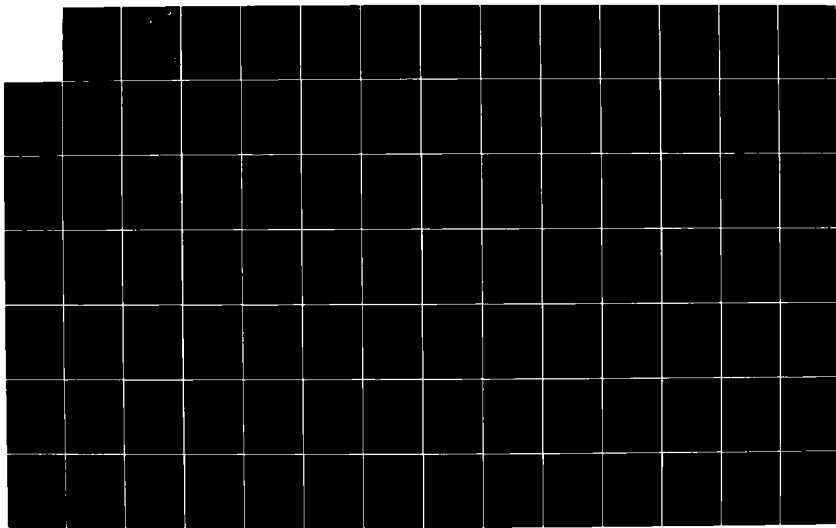
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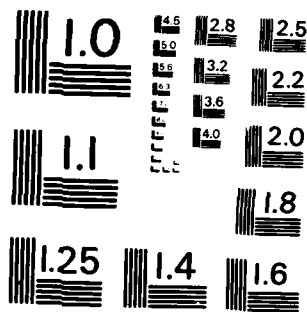
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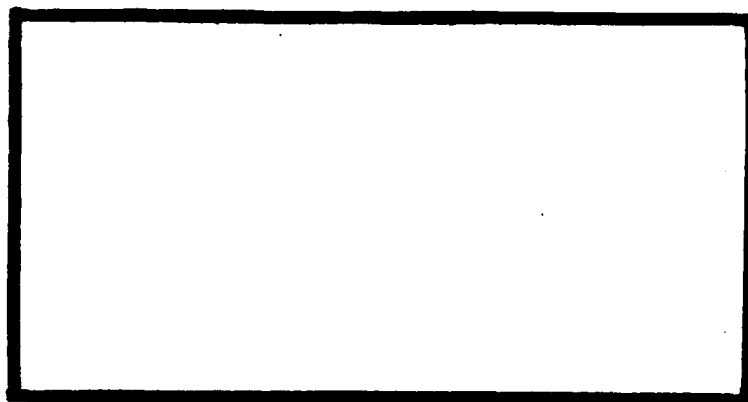


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A COMPARATIVE ANALYSIS OF SOLE SOURCE
VERSUS COMPETITIVE PRICES IN THE
ACQUISITION OF WEAPON SYSTEM
REPLENISHMENT SPARE PARTS

Edward J. Brost, GM-13

LSSR 51-82

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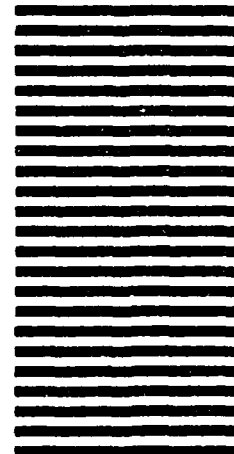


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Competition is the "law of the land" in Department of Defense procurement. Yet, buyers are continually faced with uncertainty, and the Government has no specific guidelines or firm basis for deciding when to introduce competition into the acquisition process. The overall research objective was to determine the effect of competition on the prices of weapon system replenishment spare parts. Multiple regression analysis and parametric statistical tests were used to analyze procurement history data for thirty-six replenishment spare parts, which were purchased by the Air Force Logistics Command. Price changes were attributed to three factors: inflation, order quantity, and competition. Five research hypotheses were formulated and tested to address three major research issues. Generally, the research findings contradict the results of previous empirical research and competition theory. The research results suggest that: 1) introducing competition does not guarantee lower spare parts prices; 2) for many items a portion of the price change can be attributed to the effects of competition, but competition is just as likely to raise prices as to lower prices; and 3) price changes are not influenced by changes in the number of solicitations and are similar among various commodity groups.

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Mr. Edward J. Brost

has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN LOGISTICS MANAGEMENT
(Contracting and Acquisition Management Major)

DATE: 29 September 1982

Donald Z. Brechtel

Committee Chairman

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Reader

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Chapter 1

THE RESEARCH PROBLEM

Introduction

The classical definition of a purchasing organization's objective is to buy materials and services of the right quality, in the right quantity, at the right price, from the right source and at the right time (15:11). A common principle of all types of purchasing is to obtain the greatest value for each dollar spent (15:12).

Competition is looked upon by many as one technique to maximize the return on each purchasing dollar.

Many well-meaning but grossly misinformed citizens have been led to believe that competitive bidding [i.e., formal advertising] is an assured technique for the wise expenditure of public funds [15:97].

Many members of Congress recommend the competitive method of purchasing for most Government procurement actions. However, the history of Federal procurement attests to the fact that competitive bidding is inadequate in many situations (19:42). Some authors contend that Congressional pressure has tended to force Government purchasers to overuse the competitive method of procurement (15:98).

On occasion, the push for more competitive procurement has resulted in the Government paying higher prices for some items when purchased in a competitive environment

subsequent to being procured in a sole source environment (17:93). Since competitive procurement does not always result in lower prices, program managers, contracting officers and buyers should understand the conditions which may affect prices and aggressively seek competition for items that may likely result in net savings to the Government.

Problem Statement

The Government has no specific guidelines or firm basis for deciding when to introduce competition or even if competition should be introduced into the acquisition process (16:18). Department of Defense (DoD) buyers are continuously faced with uncertainty in deciding when and what to compete (6:7). To maximize the benefits of competition, buyers need to know when introducing competition into the acquisition process will result in the Government paying lower prices for products. Buyers should also understand the factors which influence the magnitude of price changes. With this understanding, DoD buyers should be better able to emphasize the use of competition in the right areas and under circumstances which will result in lower prices to the Government.

Background

Historically, over one-half of the DoD budget has been spent for materials and services. In fiscal year (FY) 1981, DoD procurement awards amounted to \$105.2 billion,

which represented approximately 66 percent of the total DoD budget outlays (32:p.6-4; 35:80). The DoD spent these dollars by placing contracts using two procurement methods: formal advertising (i.e., competitive bidding) and negotiation.

Of the two procurement methods, competition most frequently occurs with formal advertising. However, "negotiation as a method of price determination seeks and exploits competition just as vigorously as does competitive bidding [15:100]." Competitive negotiation is often used by DoD agencies during the early phases of the weapon system acquisition process (18:15). Competitive bidding usually becomes more feasible as a weapon system moves into the latter phases of the acquisition process and for the procurement of replenishment spare parts.

A specialized case of competitive bidding is common to DoD replenishment spare parts acquisition. Frequently, the producer of a weapon system is the sole source of supply for the initial spare parts needed to maintain the weapon system. Once a weapon system is operational and specifications become firm, the DoD or the producer can make technical drawings available to other potential sources of supply (18:15). By this transfer of technology, an environment is created where DoD can competitively purchase rather than noncompetitively (i.e., sole source) purchase spare parts.

Through the years, the movement to more competitive bidding (i.e., formal advertising) seems to attract more and more proponents. However, during FY 79-81, the percentage of DoD and United States Air Force (USAF) procurement dollars spent using formal advertising (approximately 8 percent and 1½ percent, respectively) has remained relatively constant and lower than that desired by many proponents. Tables 1 and 2 summarize DoD and USAF FY 79-81 procurement awards in terms of dollars.

The low use of formal advertising is also evident in analyzing figures concerning the number of procurement awards. During FY 79-81, approximately 7 percent of DoD procurement actions involved the use of formal advertising while approximately 16 percent of USAF procurement actions involved formal advertising. Tables 3 and 4 summarize FY 79-81 procurement activity within DoD and USAF in terms of the number of procurement actions.

The low percentage use of formal advertising, in itself perhaps, may account for a portion of the emphasis placed on competition. Competition is looked upon by many as a way to lower costs, improve quality, assure adherence to the delivery schedule and generally keep both the contractor and Government honest (16:18). With so many potential benefits, it is no wonder that the push for competition has been a perpetual and growing phenomenon.

Table 1

Competition in DoD Procurement
(Dollar Value of Procurement Awards)

Type of Competition	Net Value (in thousands)			
	Fiscal Year 1979 Amount	Fiscal Year 1980 Amount	Fiscal Year 1981 Amount	Pct
TOTAL	\$70,956,014	\$83,686,442	\$105,222,886	
Intragovernmental and Foreign Military Sales	7,287,783	10,159,600	9,798,208	
Other Exclusions ¹	2,655,908	3,780,938	7,225,417	
Total, Except Above Exclusions	61,012,323	69,745,904	88,199,261	100.0
Competitive (Sub-Total)	23,801,592	25,134,175	35,915,144	36.0
Formally Advertised	5,056,166	5,595,102	6,962,098	8.0
Other Price Competition	13,034,635	13,811,875	22,471,365	19.8
Design or Technical Competition	5,710,795	5,727,198	6,481,681	8.2
Non-Competitive (Sub-Total)	37,210,725	44,611,729	52,284,117	64.0
Follow-On After Price or Design Competition	11,220,246	14,675,400	20,775,513	21.0
Catalog or Market Price (Over \$10,000 Only)	0	0	2,985,433	0.0
Other Non-Competitive	25,990,479	29,936,329	28,523,171	42.9

Source: Department of Defense Prime Contract Awards—October 1980 and 1981.

¹ Exclusions include awards for educational and non-profit institutions, utilities, the 8A program and brand name items for commissary resale.

Table 2

Competition in USAF Procurement
(Dollar Value of Procurement Awards)

Type of Competition	Net Value (in thousands)			
	Fiscal Year 1979 Amount	Fiscal Year 1980 Amount	Fiscal Year 1981 Amount	Pct
TOTAL	\$20,525,022	\$24,531,122	\$29,131,660	
Intragovernmental and Foreign Military Sales	2,616,593	4,552,227	3,677,412	
Other Exclusions ¹	828,963	1,083,136	2,765,978	
Total, Except Above Exclusions	17,079,466	19,345,759	22,688,270	100.0
Competitive (Sub-Total)	5,864,126	6,403,692	7,668,791	33.1
Formally Advertised	259,831	276,769	294,063	1.4
Other Price Competition	2,621,015	3,078,803	3,738,649	15.9
Design or Technical Competition	2,983,280	3,048,120	3,636,079	15.8
Non-Competitive (Sub-Total)	11,215,340	12,942,067	15,019,479	66.9
Follow-On After Price or Design Competition	6,424,928	8,245,411	10,809,320	42.6
Catalog or Market Price (Over \$10,000 Only)	0	0	93,509	0.0
Other Non-Competitive	4,790,412	4,696,656	4,116,650	24.3

Source: Department of Defense Prime Contract Awards--October 1980 and 1981.

¹Exclusions include awards for educational and non-profit institutions, utilities, the 8A program and brand name items for commissary resale.

Table 3

Competition in DoD Procurement
(Number of Procurement Actions)

Type of Competition	Fiscal Year 1979		Fiscal Year 1980		Fiscal Year 1981	
	Number	Pct	Number	Pct	Number	Pct
TOTAL	<u>11,405,488</u>		<u>12,071,805</u>		<u>12,745,953</u>	
Intragovernmental and Foreign Military Sales	865,021		932,049		901,422	
Other Exclusions ¹	15,053		19,840		2,291,656	
Total, Except Above Exclusions	<u>10,525,414</u>	100.0	<u>11,119,916</u>	100.0	<u>9,552,875</u>	100.0
Competitive (Sub-Total)	<u>3,815,488</u>	36.3	<u>4,412,987</u>	39.7	<u>4,594,806</u>	48.1
Formally Advertised	648,195	6.2	610,705	5.5	629,867	6.6
Other Price Competition	3,155,904	30.0	3,789,476	34.1	3,949,835	41.4
Design or Technical Competition	11,389	0.1	12,806	0.1	15,104	0.2
Non-Competitive (Sub-Total)	<u>6,709,926</u>	63.8	<u>6,706,929</u>	60.3	<u>4,958,069</u>	51.9
Follow-On After Price or Design Competition	21,939	0.2	26,066	0.2	28,853	0.3
Catalog or Market Price (Over \$10,000 Only)	0	0.0	0	0.0	5,845	0.1
Other Non-Competitive	6,687,987	63.5	6,680,863	60.1	4,923,371	51.5

Source: Department of Defense Prime Contract Awards--October 1980 and 1981.

¹ Exclusions include awards for educational and non-profit institutions, utilities, the 8A program and brand name items for commissary resale.

Table 4

Competition in USAF Procurement
(Number of Procurement Actions)

Type of Competition	Fiscal Year 1979		Fiscal Year 1980		Fiscal Year 1981	
	Number	Pct	Number	Pct	Number	Pct
TOTAL	4,107,217		4,250,611		4,430,886	
Intragovernmental and Foreign Military Sales	307,030		346,482		322,910	
Other Exclusions ¹	5,843		6,955		1,013,254	
Total, Except Above Exclusions	3,794,344	100.0	3,897,174	100.0	3,094,722	100.0
Competitive (Sub-Total)	1,960,730	51.7	2,137,618	54.9	2,099,872	67.9
Formally Advertised	498,604	13.1	466,181	12.0	495,132	16.0
Other Price Competition	1,457,741	38.4	1,666,821	42.8	1,599,541	51.7
Design or Technical Competition	4,385	0.1	4,616	0.1	5,199	0.2
Non-Competitive (Sub-Total)	1,833,614	48.3	1,752,556	45.2	994,850	32.2
Follow-On After Price or Design Competition	16,219	0.4	18,673	0.5	21,017	0.7
Catalog or Market Price (Over \$10,000 Only)	0	0.0	0	0.0	1,115	*
Other Non-Competitive	1,817,395	47.9	1,740,883	44.7	972,718	31.4

Source: Department of Defense Prime Contract Awards--October 1980 and 1981.

¹ Exclusions include awards for educational and non-profit institutions, utilities, the SA program and brand name items for commissary resale.

* Less than .05 percent.

Justification

The need for competition in the Government's acquisition of materials and services is continually stressed by Congress, taxpayers and Government officials (16:18). Since a major portion of the DoD's budget is spent on procurement, the contracting process is often subjected to close scrutiny during Congressional budget hearings. Congressional scrutiny often results in demands that more Government purchases be made using competition (34:27). The DoD, in responding to the Congressional emphasis, has initiated programs designed to increase competition in the Government marketplace.

In 1981, Deputy Secretary of Defense Frank A. Carlucci called for renewed efforts in all DoD activities to obtain maximum competition in Defense contracts (4:1). Subsequently, Under Secretary of Defense for Research and Engineering Richard D. DeLauer requested the USAF to designate advocates for competition throughout each military command (8:1). The advocates' responsibilities include finding problems and factors which inhibit competition and pursuing competitive goal accomplishments. In turn, USAF Assistant Vice Chief of Staff, Lieutenant General Hans H. Driessnack called for elimination of unwarranted sole source purchases, establishment of competitive percentage goals, and commanders to monitor performance and ensure appropriate progress is made toward goal accomplishment (8:1).

While emphasis has been placed on increasing the amount of competitive purchases, the Defense Acquisition Regulation (DAR) does not provide specific guidance to contracting officers regarding the conditions under which competitive bidding should be used. However, the DAR guidelines require the use of competition to the maximum practicable extent (31:Para.1-300.1). The DAR makes formal advertising (i.e., competitive bidding) the rule rather than the exception in Government procurement (31:Para.1-300.2). However, most procurement dollars are awarded noncompetitively, and less than 2 percent of the USAF awards are made using formal advertising (refer to Table 2).

Since use of formal advertising remains low and the pursuit of competition has not been cost effective in some instances, portions of the defense market structure may not be conducive to competitive bidding. To maximize the benefits of competition, Government buyers need to know when introducing competition into the weapon system replenishment spare parts acquisition process lowers prices and if certain factors affect the magnitude of the price changes.

Research Objectives

The overall objective of this study was to respond to the research problem by determining the effect of competition on the prices of weapon system replenishment spare parts and if certain factors influence the magnitude of price changes. Specifically, the research was to provide

an initial basis for determining under what circumstances competing previously sole source requirements results in lower prices for weapon system replenishment spare parts.

Research Issues/Hypotheses

To accomplish the research objectives, three research issues and five research hypotheses were formulated to address the stated research problem. The three research issues and associated research hypotheses are as follows:

1. Is there a reduction in replenishment spare parts prices when competition is introduced (Research Hypothesis 1)?
2. Can a portion of any price change be attributed to the effects of competition (Research Hypotheses 2 and 3)?
3. Is the magnitude of any price change influenced by certain specified factors (i.e., type of item or number of solicitations) (Research Hypotheses 4 and 5)?

The following five research hypotheses were tested in this research project.

Research Hypothesis 1

H_0 : There is no reduction in unit price when weapon system replenishment spare parts, which previously were purchased on a sole source basis, are subsequently competitively purchased.

H_a : There is a reduction in unit price when weapon system replenishment spare parts, which previously were purchased on a sole source basis, are subsequently competitively purchased.

Research Hypothesis 2

H_0 : A portion of the change in unit price, which results when competition is introduced into the weapon system replenishment spare parts acquisition process, cannot be attributed to the effects of competition.

H_a : A portion of the change in unit price, which results when competition is introduced into the weapon system replenishment spare parts acquisition process, can be attributed to the effects of competition.

Research Hypothesis 3

H_0 : The effect of order quantity on unit price is the same for both competitive and sole source purchases of weapon system replenishment spare parts (i.e., the unit price per order quantity is the same regardless of the procurement method.)

H_a : The effect of order quantity on unit price differs for competitive and sole source purchases of weapon system replenishment spare parts (i.e., the unit price per order quantity differs for each procurement method.)

Research Hypothesis 4

H_0 : The change in unit price, which results when competition is introduced into the acquisition process, is the same for all types (i.e., commodity groups) of weapon system replenishment spare parts.

H_a : The change in unit price, which results when competition is introduced into the acquisition process,

differs for at least two types (i.e., commodity groups) of weapon system replenishment spare parts.

Research Hypothesis 5

H_0 : The change in unit price, which results when competition is introduced into the weapon system replenishment spare parts acquisition process, remains the same as the number of solicitations changes.

H_a : The change in unit price, which results when competition is introduced into the weapon system replenishment spare parts acquisition process, differs as the number of solicitations changes.

Scope of Research

The data base used for this study consisted of spare parts purchases made by the five Air Force Logistics Command Air Logistic Centers during the last four years (FY 78-82). The universe included procurement actions for weapon system replenishment spare parts which had been both competitively and noncompetitively (sole source) purchased during the last four years (FY 78-82).

Military products are grouped into three classes according to their complexity and competitive potential (9:v). The three classes are:

1. new weapon systems and initial provisioning of spare parts;
2. replenishment spare parts and components, support equipment and other specialized items; and

3. commercial off-the-shelf items.

This research project dealt with only the second class of military products. A description of items in the second class and the rationale for selecting this class of items for the research project follow a brief description of the first and third classes of military products.

The first class of military products includes the design, development, and production of new weapon systems and the initial provisioning of spare parts. For products in the first class, there are many barriers to competition and the producer of the weapon system is normally the sole source of supply (13:2). When possible, limited competition can be obtained by negotiating with a few large firms.

The third class of military products includes commercial off-the-shelf products. Off-the-shelf items have similar commercial counterparts and may be supplied by many firms. There are few barriers to competition, and the DoD usually purchases items in the third class on a competitive basis (13:18).

This research project addressed items which fall in the large area between the extremes of the first and third classes. Military products in the second class are more stable and better defined than products in the first class but less stable and less defined than military products in the third class. Most of the potential for increasing competitive procurement lies in the second class of military

products. Thus, this research project addressed the procurement of weapon system replenishment spare parts and components.

Summary List of Assumptions

1. The procurement history data used for this research project were assumed to accurately reflect the transition of weapon system replenishment spare parts from sole source to competitive procurement.

2. A price change was assumed to be attributable to three factors: 1) inflation; 2) order quantity; and 3) procurement method (i.e., sole source or competition). No formal, structured attempt was made to specifically identify or quantify other factors which potentially could influence prices.

Summary List of Limitations

1. The procurement history data used in this research study included approximately four years of data. Although past procurement history data are maintained; time limitations and data accessibility prevented complete procurement histories from being obtained in time for use in this study. Thus, the author's original research plan, which included the use of a learning curve formulation to estimate sole source purchase prices, was revised. With the effects of learning omitted from the multiple regression models, the sole source price predictions may be slightly overstated.

2. A criterion for sample selection, that consecutive competitive purchases (at least three) followed consecutive sole source purchases (at least three), was included to eliminate any effects caused by repeated switching back and forth between sole source and competitive purchases. This limitation significantly reduced the sample size.

3. Due to the small sample size and variability of the price changes, no attempt was made to validate the assumptions, specified in Chapter 3 (i.e., normalcy and constant variance) and made prior to accomplishing the statistical tests of the research hypotheses.

4. No formal, structured attempt was made to specifically identify or quantify other factors which potentially could influence prices. However, during the course of this research project, the author identified many factors, other than the three included in this research project, which also could influence prices.

Summary

Chapter 1, the Research Problem, presented a statement of the research problem, background information, justification for the research effort, the research objectives, research issues/hypotheses, scope of research, and summary lists of assumptions and limitations.

The research problem concerns the role of competition in the acquisition of weapon system replenishment spare parts. There is a general consensus that competition results

in lower prices. Accordingly, the DoD has placed emphasis on increasing the amount of competitive buys. Current procurement regulations make competitive bidding the rule rather than the exception in Government procurement. However, the regulations provide little guidance concerning under what conditions competitive bidding results in lower prices.

This research study was undertaken to determine if the introduction of competition into the weapon system replenishment spare parts acquisition process actually results in lower prices. A secondary purpose of the research project was to determine if certain specified factors influence the magnitude of price changes.

To serve as a framework for this research effort, a review of the literature was conducted. Chapter 2, Literature Review, provides the results of the examination of the relevant literature on the subject of competition in procurement. The literature review included the areas of competition theory, regulatory guidance, and empirical studies concerning the effects of competition on prices.

Chapter 2

LITERATURE REVIEW

Introduction

Before the analysis of competitive versus sole source prices of weapon system replenishment spare parts was accomplished, a foundation for that analysis was established. This chapter provides the results of the literature review which served as the foundation for this research project.

The relevant literature is categorized into three general areas: competition theory, regulatory guidance, and empirical research. In the area of competition theory, competition is first defined, the role of competition in various theoretical market structures and the DoD marketplace is discussed, and then the criteria for using competitive bidding are highlighted. In the area of regulatory guidance, synopses of current military procurement regulations, the evolution of military procurement law, and DoD programs designed to increase competition are provided. Finally, in the area of empirical research, the methodologies and results of five major studies, which dealt with the subject of competition in military procurement, are summarized.

Competition Theory

Competition defined. Webster defines competition as "the effort of two or more parties to secure the custom of a third party by the offer of the most favorable terms [11:464]." A working definition of price competition used in DoD acquisition is contained in the Defense Acquisition Regulation (DAR). DAR states:

Price competition exists if offers are solicited and (i) at least two responsible offerors, (ii) who can satisfy the requirements, (iii) independently contend for a contract to be awarded to the responsive and responsible offeror submitting the lowest evaluated prices, (iv) by submitting price offers responsive to the expressed requirements of the solicitation. Whether there is price competition for a given procurement is a matter of judgment to be based on evaluation of whether each of the foregoing conditions is satisfied. Generally, in making this judgment, the smaller the number of offers, the greater the need for close evaluation [31:Para.3-807.7].

Competition and the defense market structure. Modern price and economic theory classifies markets by degrees of competition (20:2). Product prices may depend in part on the amount of competition in the marketplace. The amount of competition in the market depends on the type of market structure. A typical range of market structures is illustrated in Figure 1 (18:p.15-12).

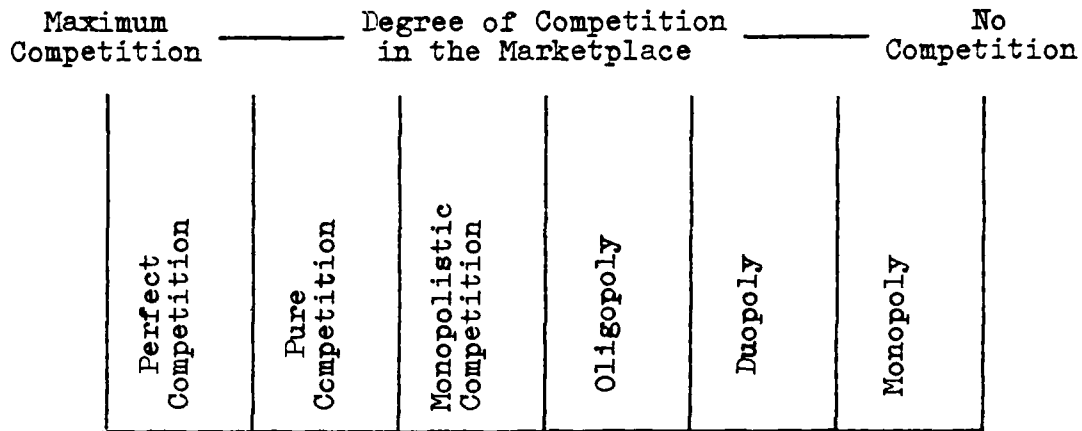


Figure 1
Market Structure Spectrum

In perfect competition, the market is characterized by many buyers and sellers with no single firm able to control price, homogenous products, free mobility of resources and perfect market knowledge (10:241). In the perfectly competitive market, price is set by the marketplace. Theoretically, in the perfectly competitive market, the competitive forces should result in the lowest prices (20:2). However, Jacques S. Gansler, a former Deputy Assistant Secretary of Defense for Material Acquisition, has stated that,

The free-market system is not operating to achieve economically efficient or strategically responsive behavior in the area frequently referred to as the 'military industrial complex' [9:1].

In a monopoly, the other extreme of the market structure spectrum, the market is characterized by one seller, a unique product, many barriers to market entry and exit, and imperfect market knowledge (10:277). In a monopoly, market results normally include higher profits and prices, less output, less employment, and lower wages as compared to a perfectly competitive market (3).

Within DoD, purchases may be made from firms in any of the market structures. While attempts have been made to classify the defense marketplace, the diversity of products makes a singular DoD market structure classification inappropriate, if not impossible (18:p.15-12). However, due to the highly specialized and technical nature of many weapon system components, the defense market structure has often been described as a bilateral monopoly (18:p.15-12; 10:275).

In a bilateral monopoly, there is one seller and one buyer (10:275). The DoD, in its quest for highly complex and state-of-the-art weapon systems, is the single buyer. Due to the large investment required, the single source of supply is usually a large firm with the capability to develop products which meet the DoD's highly specialized needs. Based on market segmentation and product specialization, classifying the defense market structure as a bilateral monopoly may be appropriate (18:p.15-12).

In order to determine when the defense marketplace lends itself to competition, a review of the criteria for using formal advertising was necessary.

Criteria for using formal advertising. It is important to understand the circumstances under which competitive bidding usually results in lower prices for items. Generally, four criteria dictate when competitive bidding is the best method of pricing (15:97). When all four criteria are present "competitive bidding assures the buyer of obtaining the lowest possible price [15:97]."

The four criteria are: 1) the dollar value of the purchase is large enough to warrant the expenses of both buyer and seller; 2) explicit specifications describing the items are available; 3) an adequate number of sellers are willing to price competitively to get the contract; and 4) sufficient time is available for using the competitive method of procurement (15:97).

The presence of the four criteria in the defense marketplace is often questionable. However, competitive bidding has been and continues to be the preferred Government procurement method (31:Para.1-300.2).

Regulatory Guidance

Competition and its role in military procurement. One of the main reasons that formal advertising is the preferred procurement method is that lower prices usually result since competition "perfectly evaluates the many pricing factors bearing on the purchase [15:98]." However, questions concerning when and what products to compete are continually faced by Government buyers.

DoD buyers use two methods to place contracts: formal advertising and negotiation (18:p.15-13). Competition is normally associated with formal advertising. However, even negotiated procurements may involve competition.

Competition is the "law of the land" in DoD procurement (31:Para.1-300.2). Government policy dictates competition, particularly formal advertising, as the preferred method of acquisition. The DAR states:

Purchases and contracts for supplies and services shall be made by formal advertising in all cases in which the use of such method is feasible and practicable under the existing conditions and circumstances [31:Para.1-300.2].

Even in situations where formal advertising is impractical, the Government requires the use of competition. The DAR further states: "All procurements, whether by formal advertising or by negotiation, shall be made on a competitive basis to the maximum practicable extent [31:Para.1-300.1]."

To understand why competition, particularly formal advertising, is the "law of the land" in DoD procurement, it is necessary to have an awareness of the evolution of Federal and military procurement law.

Evolution of procurement law. The procurement laws of today evolved from the legislative process that began shortly after the founding of the United States.

From the beginning Federal procurement has been guided by the need to acquire goods and services of specified quality on a timely basis by maximizing

competition and obtaining reasonable prices with the assurance that Government officials are publicly accountable for their actions [29:72].

The first law dealing with Federal procurement in the United States was passed by Congress in 1792 (19:24). Under this first law, the Department of Treasury was given authority to purchase supplies and services. In 1798, Congress authorized the Departments of War and Navy to make their own purchases (19:24).

Almost immediately, Congressional interest in Federal procurement became a subject of controversy (29:72). Congress did not act as watchdogs, but rather used their influence to obtain Government contracts for their friends and their own companies. Graft and favoritism soon became the rule rather than the exception in Government contracting. As a result of these abuses, Congress passed the Procurement Act of March 3, 1809 (29:72). The Procurement Act, for the first time, required all Federal purchases and contracts be made by formal advertising or placed on the open market (29:72).

In 1829, the United States Attorney General ruled that advertising be used in all military procurements except when public emergencies required the immediate performance of the contract (36:310). Between 1842 and 1860, numerous other laws established requirements for formal advertising (29:72).

The Civil Sundry Appropriations Act of March 2, 1861 governed procurement during the Civil War (29:72). The Civil Sundry Appropriations Act required formal advertising for all purchases but authorized a second exception: contracts for personal services did not have to be competitively bid (19:24). Immediately after the Act was passed, a third exception was authorized. Allowing negotiated procurements when competition was impractical was the third exception written into law (19:24).

In 1910, Congress modified Revised Statute 3709 to reemphasize formal advertising as the required method of procurement with limited exceptions (29:72). The rigid requirements for formal advertising of Revised Statute 3709 continued as the basic procurement statute until the enactment of the Armed Services Procurement Act of 1947 (29:72).

A switch from procurement by advertising occurred during World Wars I and II. During the war years agencies connected with the war effort were authorized to enter into contracts without regard to existing provisions of law, if deemed necessary to expedite the war effort (29:73). However, because of charges of profiteering by World War I contractors, restrictions were placed on contractors' profits during World War II. On March 3, 1942, the Chairman of the War Production Board prohibited all contracting by formal advertising unless specifically authorized (19:24). Thus, during the war years, practically all military procurement was conducted by negotiation.

On May 19, 1948, as a result of a study by the War and Navy Departments, the Armed Services Procurement Act of 1947 became effective (29:74). The Armed Services Procurement Act still represents the basic framework for all military procurement. The Act required "contracts for property or services to be formally advertised, except under seventeen specific situations where negotiations could be used [19:25]."

The seventeen exceptions, still applicable today, are:

1. National emergency
2. Public exigency
3. Purchases not more than \$10,000
4. Personal or professional services
5. Services of educational institutions
6. Purchases outside the United States
7. Medicines or medical supplies
8. Supplies purchased for authorized resale
9. Perishable or nonperishable subsistence supplies
10. Supplies or services for which it is impracticable to secure competition by formal advertising
11. Experimental, developmental or research work
12. Classified purchases
13. Technical equipment requiring standardization or interchangeability of parts
14. Technical or specialized supplies requiring substantial initial investment or extended period of preparation of manufacture
15. Negotiation after advertising
16. Purchases in the interest of national defense or industrial mobilization
17. Otherwise authorized by law [31:Para.3-201 to 3-217].

Of the seventeen exceptions, number ten was the most often cited by DoD and USAF in FY 81 when making non-competitive purchases (32:pp.6-17,6-18).

Since 1947, Congress has continued to place emphasis on formal advertising and competition. "Congress has

assumed an increasingly active, informed, pervasive, and at times perverse role in source selection decisions [33:2]." Today, the push for competition is as great as ever before.

DoD efforts to increase competition in procurement. DoD, in response to Congressional pressure, has initiated programs to increase the amount of competitive procurements (4:1). Among programs initiated in part to increase competition were two-step formal advertising, component breakout, high dollar spare parts breakout, multi-year procurement, leader-follower, and licensing.

Two-step formal advertising is similar to one-step formal advertising but is used when definite specifications or complete descriptions of the required items are not available (19:37; 31:Para.2-501). The first step consists of a request, submission and evaluation of a technical proposal to determine the acceptability of the design and production plan. The second step, concerned with price bids and award of the contract, is the same as in one-step formal advertising, except invitations for bid are only sent to contractors with acceptable technical proposals (19:37).

Component breakout is a program in which the Government purchases major system components directly from vendors and furnishes the items to the prime contractor of the weapon system as Government Furnished Property (31:Para. 1-326). Direct competitive purchases are intended to result in substantial savings since the items "broken out" usually

cost in excess of \$1,000,000 (31:Para.1-326.1).

The High Dollar Spare Parts Breakout Program was established by DoD in 1969 and is similar in purpose to the component breakout program (33:1). The program was designed to increase competition for those spare parts which, when ranked in descending order of annual buy value, accounted for at least 80 percent of all dollars expected to be spent in a twelve month period for weapon system spare parts (33:p.1-5).

Multi-year procurement was designed to encourage business firms to bid on contracts by assuring continued production over a specified number of years (31:Para.1-322.1 (b)(vii)). Since contractors would be guaranteed a certain amount of follow-on business, the multi-year approach provides incentives for businesses to enter the defense market.

The leader-follower and licensing techniques were designed to develop new sources of supply (31:Para.4-701 (vii),9-301.1). With these two techniques, the developer or sole producer of an item furnishes manufacturing assistance or transfers technology to another company enabling the second company to become a source of supply for the particular item. By developing other sources of supply, the opportunity for competing subsequent requirements is increased, and there is a greater assurance of receiving timely delivery (6:45).

Even though DoD has instituted many programs to increase the amount of competition in procurement, the real

benefits of competition in the defense marketplace remain a subject of controversy. Several empirical studies have addressed the subject of the benefits of competition. Many of the studies were specifically designed to determine the amount of savings the Government realized when competition was introduced into the major weapon system acquisition process. Only a few of the studies dealt specifically with spare parts procurement.

In the next section, a summary of the research methodologies and results of five applicable studies is presented.

Empirical Research

Major empirical studies. Results of initial research studies concerning the benefits of competition were reported by the Southwestern Legal Foundation in 1963 (18:p.15-16). The Foundation reported that the combination of adequate specifications and two or more qualified sources resulted in price reductions on the average of 25 percent (18:p.15-16).

In 1965, then Secretary of Defense Robert S. McNamara reported to the Joint Economic Committee (Hearings on the Impact of Federal Procurement) that the General Accounting Office had evidence of dollar savings in the range of 25 percent or more when an item was competitively purchased after initially being purchased on a sole source basis (13:1). The DoD still recommends the 25 percent figure be used when performing economic evaluations on component breakout candidates (33:p.3-15).

Authors accomplishing empirical research since 1965 estimated price savings of between 7 and 50 percent when competition was introduced into the acquisition process (18:p.15-16). However, in some of the same research studies, the authors found that competing some requirements actually cost the Government more money than when the items were purchased on a sole source basis (17:93).

The research methodologies used to estimate savings in the previous studies varied widely. To aid in developing a methodology for this research project, the methodologies and results of five studies were examined. The methodologies and results are briefly discussed in the following sections.

A synopsis of research study 1. In 1972, the Comptroller, U.S. Army Electronics Command measured the savings achieved when competition was introduced into the procurement process for twenty different systems managed by the Army Electronics Command (5). The average savings in unit price for these twenty systems amounted to 56 percent. Cost analysts measured the difference between the unit price of the last sole source buy and the unit price of the first competitive buy and attributed the entire price change to the effects of competition. No attempt was made to estimate a sole source price that would have been paid had competition not been introduced.

The cost analysts also attempted to develop a model which could predict and relate causal factors to expected

savings. However, for the items analyzed, no conclusive cause/effect relationships were substantiated (5).

A synopsis of research study 2. In a 1974 study conducted at the Air Force Institute of Technology (AFIT), Olson, Cunningham and Wilkins analyzed 356 items which the USAF originally purchased sole source and subsequently competitively purchased (24). The study showed that the introduction of competition into the acquisition of spare parts accounted for a decrease in unit price between 10.8 percent and 17.5 percent, depending on the size of the order. Order quantities and prices were standardized in order to fit one regression model to all the data. As in the first empirical study, no attempt was made to estimate a sole source price for the first competitive purchase. The percentage price reduction represented the difference between the prices of the last sole source buys and the first competitive buys (24:65).

In light of this small amount of savings for spare parts purchases, the authors postulated that any small increase in costs, incurred when requirements were competed, may tend to offset the savings in some instances. The authors identified four factors with the greatest potential to offset the gross savings. The four factors were: 1) procurement data costs; 2) administrative costs; 3) quality costs; and 4) reliability costs (24:22).

Olson, Cunningham and Wilkins subjectively analyzed, mainly through discussions with operating personnel, three of the four offsetting factors. The authors' subjective appraisal was that, of the three factors, quality costs was the only factor which could possibly offset any gross savings. Olson, Cunningham and Wilkins concluded that spare parts competitively purchased, especially the low cost spares, tended to be of a poorer quality than those purchased on a sole source basis (24:85).

A synopsis of research study 3. In 1978, a joint study was conducted by the U.S. Army Procurement Research Office and Telecote Research, Inc. (17). Lovett and Norton developed a methodology to estimate savings resulting from introducing competition into the acquisition process for sixteen Army weapon systems, over half of which were missile systems and subsystems. The savings by item ranged from a loss of 13.2 percent to a gain of 51 percent. In the study, a 10.8 percent gain was the average saving (17:93).

To estimate net savings, Lovett and Norton developed a basic accounting model with savings debits and credits. In the research methodology, the authors took into consideration hardware unit prices, non-recurring and start-up costs, learning, and inflation (17:10). However, administrative costs incurred due to competition were not addressed. The inclusion in the estimating model of cost improvement (learning) curves for both the pre and post competitive

awards allowed for a more realistic determination of the change in price which could be attributed specifically to the effects of competition (17:11).

A second major objective of the research project was to develop a methodology to forecast the net savings expected from introducing competition into the procurement of future items (17:1). Lovett and Norton developed a three part forecasted savings methodology (17:68). The first part was a competition screen, or set of criteria, that must be met in order to consider competition. The second part was a forecasting model which provided an estimate of expected savings by considering quantitative factors. The third part was a competition index which summarized an analysis of the qualitative factors which influence savings. Lovett and Norton's forecasted savings methodology was useful because the methodology allowed for consideration of both quantitative and qualitative factors in making savings estimates (17:68).

A synopsis of research study 4. In 1979, Daly, Gates and Schuttinga conducted an extensive study for the Institute for Defense Analysis (6). The research study concerned the impact of price competition on weapon systems acquisition costs. The researchers examined the impact of competition on both price and non-price aspects of acquisition costs, the importance of cost/quantity relationships for measuring the effect on price, and problems in developing multiple

sources. The researchers also reviewed the savings forecast methodologies developed in previous studies (6).

Daly, Gates and Schuttinga reviewed the data of thirty-one major components which were examined in a previous study and applied the data to the authors' own model. The researchers concluded that: 1) the use of price competition should be evaluated as an investment decision; 2) although mixed results have been experienced, generally, the use of price competition has represented cost effective investments of scarce resources; 3) competition will increase costs in the short run but decrease costs over the long run; 4) the flatter the learning curve, the more likely savings are to result from competition; and 5) one can reasonably expect different kinds of military items to yield different expected savings under competition (6:p.s-4).

A synopsis of research study 5. In a 1981 study sponsored by the U.S. Army Procurement Research Office, Smith and Lowe examined the price behavior of a sample of thirty-nine Army helicopter and major component spare parts which were competitively purchased after the items were initially purchased on a sole source basis (26). In addition to estimating the percentage savings realized on the first competitive buy, the researchers analyzed whether competitive procurements reflected a steeper learning (experience) curve than sole source procurements (26:1).

Smith and Lowe concluded that a reasonable percentage savings estimate is likely to be between 15 and 25 percent depending upon the system (26:9). Another conclusion was that the sole source and competitive learning curve slopes were nearly equal. However, the authors also noted that the competitive slope was slightly improved (flatter) and had greater variability than the sole source slope (26:9).

The overall conclusion drawn from the results of the previous empirical studies is that switching to competitive procurement from sole source procurement resulted in price reductions. However, in certain instances, price reductions were not as great as originally anticipated. The research results tend to partially support Kottke who said, "much procompetitive effort yields a meager return [14:544]."

Summary

This chapter presented the results of an examination of the literature on the subject of competition in procurement. Relevant information in the areas of competition theory, regulatory guidance, and empirical research was discussed in order to lay a basic framework for this author's research project.

The benefits of competition vary depending upon the type of market structure in the DoD marketplace. The defense marketplace is often described as a bilateral monopoly. Often there is disagreement over whether the military marketplace is conducive to competitive bidding. However,

competition remains the "law of the land" in military procurement.

Throughout most of U.S. history, competitive procurement has been the Government's preferred method of purchasing. DoD has initiated many programs to increase the amount of competitive procurement. Results of empirical research studies indicate that switching from sole source to competition usually results in price decreases between 10 and 25 percent. However, introducing competition into the acquisition process did not always guarantee lower prices.

To maximize the potential benefits from competition, decision makers need to know when and under what circumstances the introduction of competition into the acquisition process will result in lower prices. The next chapter presents a detailed discussion of the research methodology used to accomplish the research objectives formulated in Chapter 1.

Chapter 3

RESEARCH METHODOLOGY

Introduction

The overall objective of this research study was to determine the effect of competition on the prices of United States Air Force (USAF) weapon system replenishment spare parts. This chapter provides a detailed explanation of the research methodology that was developed and applied to accomplish the research objectives. The chapter discusses the data base, data collection, sample selection, data transformation and statistical techniques used in the research study. The specific approaches designed to test the five research hypotheses are then discussed.

Data Base

Within the USAF, the responsibility for spare parts acquisition lies with the Air Force Logistics Command (AFLC) (19:4). AFLC delegates the acquisition responsibility to five Air Logistics Centers (ALC). Each ALC is responsible for purchasing spare parts for particular weapon systems. Whenever spare parts purchases are made, the ALC updates a procurement history file with pertinent facts of each purchase. Examples of the data maintained in the procurement history files include national stock number, purchasing

office, order quantity, price, priority, procurement method code, number of solicitations, contract type, etc. Within AFLC, the current procurement history files include approximately four years of data. The procurement history files are maintained as part of the Acquisition and Due-In System (JO41) (1:p.1-1).

Data Collection

For this research study, the data base consisted of procurement history files for all USAF spare parts procurement actions accomplished at the five ALCs during the four year period ending March 1982. A Common Business Oriented Language (COBOL) program (28) was used to tally the number of replenishment spare parts procurement actions (1:p.A1-30). During the four year period ending March 1982, the five ALCs procured 198,308 replenishment spare parts (line items) representing 339,553 individual procurement actions and amounting to over \$1,291,093,000.

Since the main objective of this research project involved determining the change in price which resulted from switching to competitive procurement from sole source procurement, replenishment spare parts which had been purchased in both procurement situations (i.e., sole source and competition) were identified.

The number of solicitations, which is one of the data elements on the procurement history file, for each individual procurement action of the 198,308 line items was

analyzed using the previously mentioned COBOL program. If the procurement history file for a particular spare part had procurement actions and the data element, number of solicitations, was coded with both a "1" (i.e., one source solicited: sole source purchase) and something other than "1" (i.e., two or more sources solicited: competitive purchase), the item was considered a candidate for analysis in the research project.

Procurement history data for the candidate items were then transferred from the ALC procurement history files to local disc files. The procurement history data were transferred to disc files to permit direct access to the data during statistical analysis.

A total of 12,747 replenishment spare parts representing 53,191 procurement actions and amounting to over \$349,000,000 were both competitively and noncompetitively purchased by the five ALCs during the four year period ending March 1982. Table 5 summarizes, by individual ALC, the population of data for this research study.

Table 5

Replenishment Spare Parts Procurement
History Data (FY 78-82)

<u>Air Logistics Center</u>	<u>Competitive and Noncompetitive Purchases</u>	
	<u>Number of Spare Parts (Line Items)</u>	<u>Number of Individual Procurement Actions</u>
San Antonio	4,722	22,442
Oklahoma City	1,819	6,950
Ogden	2,577	10,942
Sacramento	1,770	6,407
Warner Robins	<u>1,859</u>	<u>6,450</u>
TOTAL	12,747	53,191

Sample Selection

Before selecting a sample for data analysis, the data were categorized by number of procurement actions per procurement method for each replenishment spare part. Specifically, a Formula Translating (FORTRAN) program (2) was used to identify all items with at least three competitive and noncompetitive procurement actions annotated on the ALC procurement history files.

Of the 12,747 replenishment spare parts which had been both competitively and noncompetitively purchased, a total of 989 replenishment spare parts (line items) were both competitively and noncompetitively purchased at least three times. Procurement history data for the 989 items

were manually screened to ensure the accuracy and completeness of the data. The screening process was also used to ensure that consecutive sole source actions were always followed by consecutive competitive actions.

A small number of procurement actions were deleted from sample consideration because of inaccurate pricing data. Numerous items, which transitioned back and forth between sole source and competitive procurement, were also deleted from sample consideration. The result of the screening process was that thirty-six weapon system replenishment spare parts representing 442 procurement actions and amounting to approximately \$7,000,000 remained in the sample and were used in the data analyses for this research project.

Data Transformation

To eliminate potential bias that may be caused by the effects of inflation, all prices of the weapon system replenishment spare parts were adjusted to constant year dollars (1980 base year) using the Producers Price Index (PPI) for special metals and metal products (30). The PPI measures average changes in prices received by producers of commodities in all stages of production in primary markets of the United States. The PPI uses 1967 as a base year. Nearly 2,800 commodities from the major sectors of the U.S. economy are included in the PPI. The PPI was originally known as the Wholesale Price Index.

The specified contract award date for each procurement action on the ALC procurement history files was used for the price index adjustments. All prices were converted to 1980 constant year dollars by dividing the actual unit price by the quotient of the average annual index for the particular year divided by the 1980 average annual index. Table 6 provides a summary of the price index factors and example adjusted unit price computations expressed in 1980 base year dollars. The adjusted unit prices were used in all of the statistical analyses. All figures presented in subsequent chapters represent 1980 constant year dollars.

Statistical Techniques

Multiple regression analysis, analysis of variance, and large and small sample tests of hypotheses about population means were the primary statistical tools used for data analyses in this research project. The Statistical Package for the Social Sciences (SPSS) was the computer program used to accomplish the statistical analyses (23). Regression modeling is designed to build a model by fitting a least squares regression line to a set of data (21:294, 298). Specifically, regression refers to the measurement of the relationships among two or more variables (12:551).

The general form of a multiple regression model is:

$$Y = B_0 + B_1X_1 + B_2X_2 + \dots + B_kX_k + e \quad (21:337)$$

where Y represents the dependent variable which is a

Table 6
Price Index Factors and Example Computations
of Adjusted Unit Prices

<u>Award Date</u>	<u>Actual Unit Price (then year dollars)</u>	<u>PPI Factor</u>	<u>1980 Factor*</u>	<u>Adjusted Unit Price (1980 Dollars)**</u>
1978	\$100.00	2.096	.810	\$123.46
1979	100.00	2.346	.907	110.25
1980	100.00	2.585	1.000	100.00
1981	100.00	2.794	1.081	92.50
1982	100.00	2.865	1.108	90.25

* 1980 Factor = PPI Factor/2.585.

** Adjusted Unit Price = Actual Unit Price/1980 Factor (Represents value of purchase expressed in 1980 dollars (e.g., \$100.00 spent in 1982 bought the same amount of goods that \$90.25 did in 1980, and \$100.00 spent in 1978 bought the same amount of goods that \$123.46 did in 1980)).

function of k independent variables ($X_1, X_2 \dots X_k$). A random error term (e) is included to make the model probabilistic rather than deterministic. The values of the coefficients ($B_1, B_2 \dots B_k$) represent the contribution of the independent variables to the prediction of Y . B_0 is the y -intercept.

In order to apply regression analysis, four assumptions concerning the probability distribution of the random error component (e) were made (22:30,31). The four assumptions were that all errors were: 1) independent; 2) normally distributed; 3) with a mean of zero; and 4) constant variance for all values of the independent variables.

A stepwise regression procedure was used to build pricing models for each of the items in the sample. In the stepwise procedure, variables are entered into the regression models in order of importance (21:411). The results of the stepwise procedure is a model containing only the independent variables which have the main effects on the dependent variable (21:412). Although the stepwise procedure does not guarantee the best possible model, the procedure has been judged by some statisticians as the best variable selection procedure available (7:172).

Once the regression models were formulated, three techniques were used to test the validity and utility of the models. These model evaluation techniques were applied in testing Research Hypotheses 2 and 3, which were previously formulated in Chapter 1. The three techniques were

the coefficient of multiple determination (R^2), global F test, and student's t test. Since detailed descriptions of the three techniques are readily available in statistics texts (7; 12; 21; 22; 27), only brief explanations of the techniques are provided in this discussion.

The coefficient of multiple determination (R^2) was used to measure how well the individual thirty-six regression models fit the respective data associated with each of the thirty-six items in the sample. The R^2 represents the models ratio of explained variance to total variance (27:600; 7:26). Stated another way, the R^2 measures the proportion of total variance about the mean of a dependent variable that can be attributed to the relationship between the independent and dependent variables specified in the regression models (12:517). The R^2 value is always between zero and one. The regression model has more utility (i.e., explains more total variance) as the R^2 value approaches one (21:350).

The global F test was used to test the adequacy and utility of the thirty-six individual multiple regression models. A large F value indicates the model is useful (21:351). Generally, the F statistic becomes large as the coefficient of multiple determination approaches one (21:351).

The student's t test was used to test the significance of the individual independent variables (21:345).

If the coefficients of the independent variables were judged to be significant, the conclusion was made that the particular independent variable did contribute information for the prediction of the dependent variable.

The Z and t statistics were used to evaluate Research Hypothesis 1 (21:220,231). The Z statistic (large sample test) was used for the first two tests of the first hypothesis, and the t statistic (small sample test) was used for the third and fourth tests of Research Hypothesis 1. The results of the Z and t tests allow conclusions, regarding the population means, to be drawn (21:220,231). For purposes of this research study, rejection of the first null hypothesis would indicate that prices decrease when competition is introduced into the replenishment spare parts acquisition process.

A ONEWAY analysis of variance was performed to accomplish the tests of Research Hypotheses 4 and 5 (23:422). In the analysis of variance test, the replenishment spare parts were categorized by specified criteria (i.e., commodity group and number of solicitations), the mean price change was computed for each category, and then the mean price changes for the categories were compared.

For all of the hypotheses tests, rejection of the null hypotheses (H_0) led to acceptance of the conditions specified in the alternative hypotheses (H_a). Alternatively, if the null hypotheses were not rejected, no conclusion was

made regarding the conditions specified in the null or alternative hypotheses. All of the statistical tests were accomplished at the .05 level of significance in order to maintain a low probability of rejecting the null hypotheses when in fact the null hypotheses were true (12:311).

The foregoing statistical techniques were incorporated within the overall research methodology which was designed to examine three major research issues.

Research Issues

Three major issues were addressed in this research project. The research issues concerned the introduction of competition into the weapon system replenishment spare parts acquisition process. The three research issues were:

1. Is there a reduction in replenishment spare parts prices when competition is introduced?
2. Can a portion of any price change be attributed to the effects of competition?
3. Is the magnitude of any price change influenced by certain specified factors (i.e., type of item or number of solicitations)?

A synopsis of the basic research design developed to address each of the three research issues is provided below. For the reader's convenience, the research issues and research hypotheses are restated prior to discussing the details of the specific research methodologies.

Basic Research Methodology

Figure 2 provides a pictorial view of the overall research design and a summary of the relationships between the three major research issues and the five research hypotheses.

Research Issue 1. Is there a reduction in replenishment spare parts prices when competition is introduced?

Research Hypothesis 1

H_0 : There is no reduction in unit price when weapon system replenishment spare parts, which previously were purchased on a sole source basis, are subsequently competitively purchased.

H_a : There is a reduction in unit price when weapon system replenishment spare parts, which previously were purchased on a sole source basis, are subsequently competitively purchased.

Research Hypothesis 1, which involved the computation of the change in unit price when competition was introduced into the acquisition process, was evaluated in four separate tests.

The first test of Research Hypothesis 1 involved comparing the unit price of the last sole source purchase to the unit price of the first competitive purchase for each of the thirty-six line items. The second test of Research Hypothesis 1 involved comparing the average of the

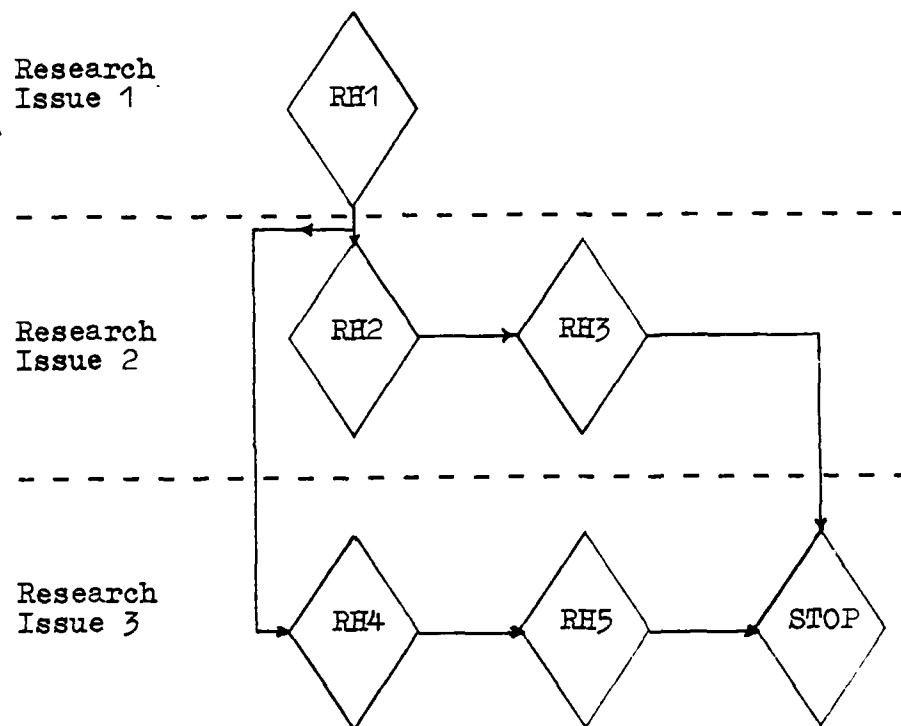
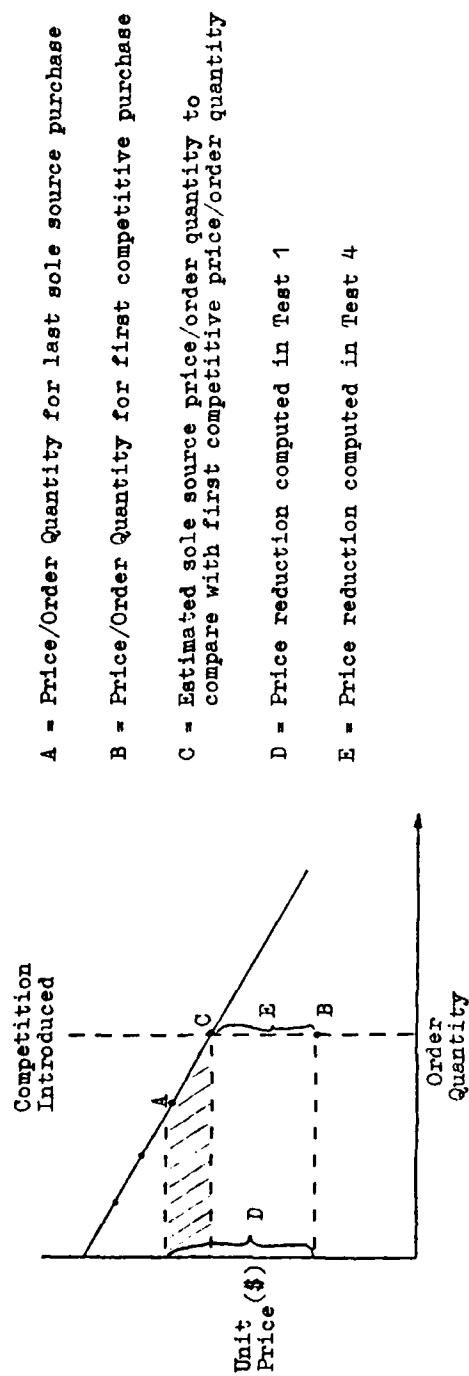


Figure 2
Research Design Summary of Relationships
Between Research Issues and
Research Hypotheses (RH)

sole source unit prices to the average of the competitive unit prices for each weapon system replenishment spare part. The third test of Research Hypothesis 1 involved the same data set used in the second test, except items with price changes greater than plus or minus 50 percent were deleted from the sample prior to testing.

The fourth test of Research Hypothesis 1 involved the use of least squares regression equations to predict sole source prices for comparison with the prices of the first competitive purchases. Details of the regression analysis are discussed in the next section. Specifically, the regression models with high R^2 and large F values were used to predict the anticipated sole source prices that would have been paid for the items had competition not been introduced. The estimated sole source prices were then compared to the prices of the first competitive purchases of the applicable replenishment spare part. Figure 3 illustrates the definitions of terms associated with the differences between tests 1 and 4 of the first hypothesis.

In all four tests, the percent change in unit price for each line item was computed by subtracting the competitive prices from the sole source prices and dividing the result by the sole source prices. After computing the mean price change, the Z and t statistics (21:220,231), depending on the sample size, were used to test the first hypothesis. Rejection of the null hypothesis would indicate that prices



Portion of price reduction attributed to effects of factors other than competition

Figure 3

Comparison of Price Changes Computed During Tests 1 and 4 of Research Hypothesis 1

decreased when competition was introduced into the weapon system replenishment spare parts acquisition process.

Research Issue 2. Can a portion of any price change be attributed to the effects of competition?

Research Hypothesis 2

H_0 : A portion of the change in unit price, which results when competition is introduced into the weapon system replenishment spare parts acquisition process, cannot be attributed to the effects of competition.

H_a : A portion of the change in unit price, which results when competition is introduced into the weapon system replenishment spare parts acquisition process, can be attributed to the effects of competition.

Research Hypothesis 3

H_0 : The effect of order quantity on price is the same for both competitive and sole source purchases of weapon system replenishment spare parts (i.e., the unit price per order quantity is the same regardless of the procurement method.)

H_a : The effect of order quantity on price differs for competitive and sole source purchases of weapon system replenishment spare parts (i.e., the unit price per order quantity differs for each procurement method.)

To test Research Hypotheses 2 and 3, least squares regression lines were fit to the sole source and competitive portions of the procurement histories for each of the

thirty-six items. To determine if a portion of the price changes could be solely attributed to the effects of competition, the effects of other factors which could influence price were identified and controlled. As previously stated, inflation and order quantity were two other factors controlled in this study. Since the influence of inflation on prices should be obvious to the readers, only an explanation of the effects of order quantity on price is discussed below.

Generally, as the quantity purchased increases, unit prices should decrease (10:182). Two theoretical explanations support anticipated price reductions. Prices normally decrease due to: 1) economies of scale in the production process; and 2) the effects of the learning curve theory.

Total item cost can be considered to be the sum of fixed costs and variable costs. Variable costs vary directly with volume of output, while fixed costs do not vary with volume of output. Thus, fixed costs per unit decrease as volume increases, and manufacturers should be able to charge lower prices for larger orders (10:182).

The learning curve theory states that, "as the number of units produced doubles, production costs per unit decrease by some constant percentage [20:64]." Learning curve theory is based on the observation that, through repetitive production, improvements occur which result in an item being produced in less time. As previously stated, learning curve effects were not specifically included in this research study

because complete historical procurement data were not readily available for the weapon system replenishment spare parts. However, including the order quantity as an independent variable in the regression models served to account for a small part of the improvement effect (24:40).

During the regression procedure, the logarithmic and second degree functions of the independent variable quantity were introduced into the models. However, the coefficients of the logarithmic and second degree functions were not significant and did not warrant inclusion in the regression models. Thus, a linear approximation model was used to address Research Issue 2.

The basic linear regression model used to determine the effects of the procurement method (i.e., competition or sole source) and order quantity on price was:

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + e ,$$

where the variable X_1 represented the order quantity and the variable X_2 represented the procurement method. X_2 was defined as a dummy variable taking on the value "0" if the purchase was competitive or the value "1" if the purchase was sole source. X_3 represented the interaction between order quantity and procurement method (i.e., the cross product of X_1 and X_2). The error terms were represented by the symbol e , Y represented the unit price, and B_0 represented the y-intercept. Using these three variables,

regression analysis was performed for each of the thirty-six line items in the sample.

The global F test and coefficient of multiple determination were then used to test the adequacy and utility of the thirty-six complete regression models (21:352; 27:600). The student's t test was used to evaluate the significance of the individual independent variables in the regression models (21:345). The portion of the difference in unit prices which could be attributed to either the effects of order quantity or the introduction of competition into the procurement process (Research Hypothesis 2) was dependent on the significance of the coefficients of the independent variables (X_1 and X_2). Rejection of null hypotheses would indicate that the particular variables had a significant influence on price.

To determine if the effect of order quantity was the same for both sole source and competitive purchases, the slopes of the sole source and competitive least squares lines were compared (Research Hypothesis 3). To compare the slopes, the significance of the coefficient of the interaction variable, X_3 , was evaluated using the student's t test (21:345). Rejection of the null hypothesis would indicate that the slopes of the competitive and sole source regression lines were significantly different. Thus, the conclusion would be drawn that prices per order quantity change at different rates depending on the method of procurement

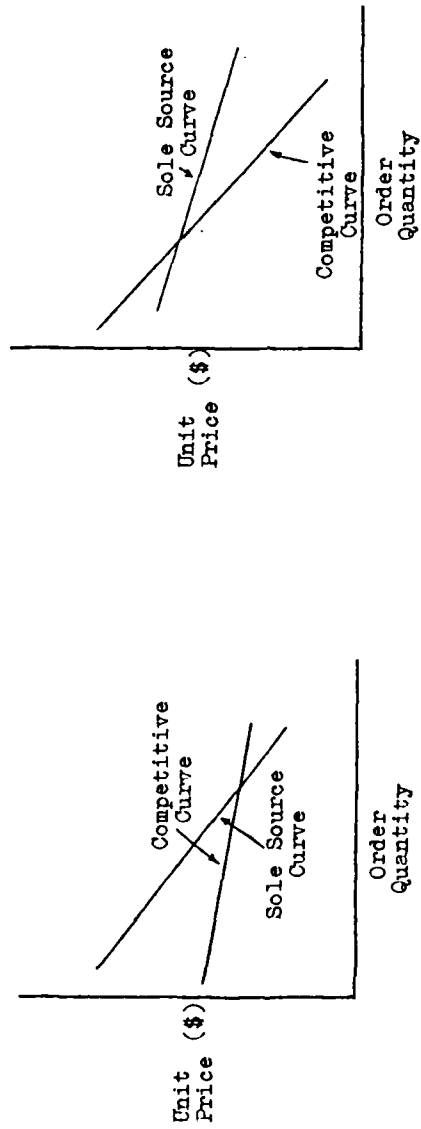
(i.e., sole source or competitive).

If the order quantity influence on prices differs for sole source and competitive procurements, long range spare parts buying decisions (i.e., whether to compete or remain sole source) should be evaluated accordingly. For instance, a competitive price/order quantity curve which is flatter than the sole source curve, would indicate that competitive prices decline at a slower rate than sole source prices as the order quantity increases. Figure 4 illustrates the relationships between two hypothetical pairs of sole source and competitive unit price/order quantity curves. Figure 4a indicates that for small order quantities competitive unit prices would be lower than sole source unit prices. Figure 4b indicates a situation where competitive unit prices would be higher than sole source unit prices for small order quantities. Thus, differences in the slopes of the competitive and sole source unit price/order quantity curves could influence spare parts pricing decisions.

Research Issue 3. Is the magnitude of any price change influenced by certain factors (i.e., type of item or number of sources)?

Research Hypothesis 4

H_0 : The change in unit price, which results when competition is introduced into the acquisition process, is the same for all types (i.e., commodity groups) of weapon system replenishment spare parts.



4a: Compete Small Order Quantities--Sole Source Large Order Quantities

4b: Compete Large Order Quantities--Sole Source Small Order Quantities

Figure 4

Relationships Between Hypothetical Sole Source and Competitive Unit Price/Order Quantity Curves

H_a : The change in unit price, which results when competition is introduced into the acquisition process, differs for at least two types (i.e., commodity groups) of weapon system replenishment spare parts.

Research Hypothesis 5

H_0 : The change in unit price, which results when competition is introduced into the weapon system replenishment spare parts acquisition process, remains the same as the number of solicitations changes.

H_a : The change in unit price, which results when competition is introduced into the weapon system replenishment spare parts acquisition process, differs as the number of solicitations changes.

Two separate tests of both Research Hypotheses 4 and 5 were performed. The data used in the first tests of these two hypotheses were the price changes computed when comparing the average sole source prices to the average competitive prices (see Research Hypothesis 1, Test 2). The second tests of Research Hypotheses 4 and 5 involved the data used in the first tests. However, items with price changes greater than plus or minus 50 percent were deleted from the sample prior to testing (see Research Hypothesis 1, Test 3).

To test whether the price changes among various commodity groups were similar (Research Hypothesis 4), the weapon system replenishment spare parts were first categorized by commodity group. A commodity group consists of

specified items which are categorized by supply class for the purpose of reporting in the DoD High Dollar Spares Breakout Program (33:p.A1-7). A description of the ten commodity groups, used by AFLC, is included in Figure 5.

After grouping the replenishment spare parts, a ONEWAY analysis of variance (ANOVA) of the price changes was performed (23:422). In the ANOVA, a mean price change was computed for each commodity group and the commodity group mean price changes were then compared. The F statistic was used to evaluate the group means. Rejection of the null hypothesis would indicate that the mean price changes differed among the various commodity groups.

To test whether the number of solicitations influenced the magnitude of the price changes (Research Hypothesis 5), the replenishment spare parts were categorized into three groups depending on the number of solicitations. The three groups consisted of: 1) two solicitations, 2) three to four solicitations, and 3) five or more solicitations.

After grouping the replenishment spare parts, a ONEWAY ANOVA was performed to compare the mean price change of each group. As in the previous statistical test, a mean price change was computed for each solicitation group and the solicitation group mean price changes were compared. The F statistic was used to evaluate the group means. Rejection of the null hypothesis would indicate that a change in the number of solicitations resulted in different price changes for weapon system replenishment spare parts.

<u>Group</u>	<u>Explanation</u>	<u>Stock Class</u>	
1	Airframe structure components	Group	15
2	Aircraft engine (gas turbine and reciprocating related spares & parts)	Class	2810, 2840, 2895, 2915, 2925, 2935, 2945, 2950, 2995
3	Aircraft subsystems, accessories, and components related spares & parts	Class	1270, 1280, 2620, 4920, 6340, 4940, 6605, 6610, 6615, 6680, 6685
4	Guided missile components and related spares & parts	Group	14
		Class	4935
5	Mechanical miscellaneous	Group	30, 39, 41, 43, 47, 48, 53
6	Vehicle spares and parts	Class	2310, 2320, 2330, 2340, 2350, 2610, 2630, 2640, 2805, 2815, 2910, 2930, 2940, 2990, 6620, Group 24, 25
7	Weapons components and related spares	Group	10, Group 12 (except 1270, 1280)
		Class	6920, 8140
8	Ammunition components and related spares and parts	Group	13
9	Electrical, electronic, and communication equip and related spares & parts	Group	58, 59, 61
		Class	6625
10	Other		

Figure 5
Commodity Groups

Source: AFLCR 70-11, Appendix 3, Attachment 1, page A1-7.

Summary

The details of the research methodology used to accomplish this research project were outlined in this chapter.

The population from which the research sample was drawn included weapon system replenishment spare parts which were purchased by AFLC during the four year period ending March 1982. A sample of items which had been both competitively and noncompetitively (i.e., sole source) purchased at least three times was selected for analysis.

After adjusting unit prices to 1980 constant year dollars in order to remove any inflationary effect, four separate price change computations were accomplished for the items in the sample. The computations were:

1. comparing the last sole source purchase prices to the first competitive purchase prices;
2. comparing the average sole source purchase prices to the average competitive purchase prices;
3. comparing the same data in 2 above after deleting items with price changes greater than plus or minus 50 percent; and
4. comparing estimated sole source purchase prices to the first competitive purchase prices.

The Z and t statistics were used to evaluate the mean price changes computed in the four tests of Research Hypothesis 1.

Multiple regression analysis was used to measure the relationships between unit price, order quantity, and procurement method (Research Hypotheses 2 and 3). ONEWAY ANOVAs were performed to evaluate the influence of commodity grouping (Research Hypothesis 4) and number of solicitations (Research Hypothesis 5) on unit price. All statistical tests were performed at the .05 level of significance.

The results of implementing the research methodology are presented in the following chapter.

Chapter 4

DATA ANALYSIS AND FINDINGS

Introduction

This chapter presents the results of the data analyses performed from implementing the author's research methodology described in Chapter 3. The chapter provides the specific findings which resulted from addressing the three major research issues and testing the five research hypotheses formulated in Chapter 1. This chapter is divided into six major sections. The first section of the chapter provides a brief discussion of the results of the sample selection process. The following sections highlight the results of the tests of each of the five research hypotheses as related to the three research issues.

Sample Selection Results

During the four year period ending March 1982, the five Air Logistics Centers (ALC) purchased 198,308 replenishment spare parts (line items), which represented 339,553 individual procurement actions. For many of the spare parts, the author anticipated that once competition was introduced for an item, subsequent purchases of that particular spare part would also be made using the competitive method of purchasing. To eliminate any bias which

could be caused by transitioning back and forth between sole source and competitive procurement, a criterion for replenishment spare parts sample selection was established. For a line item to be included in the researcher's sample at least three consecutive sole source procurement actions for a particular item must have been followed by at least three consecutive competitive procurement actions for the same item.

Of the 198,308 replenishment spare parts (line items) purchased by the ALCs, only thirty-six met the sample selection criteria. The thirty-six line items are listed in Appendix A along with the pertinent data used in the research hypotheses tests. A sample size of thirty-six would normally be large enough to make projections about an entire population. However, as will be discussed in later sections, the extreme variability in the computed spare parts price changes resulted in many inconclusive tests. Accordingly, unqualified projections concerning the effects of competition on the prices of weapon system replenishment spare parts were considered inappropriate for this research project. Thus, the results of this research study should be considered as preliminary research findings which warrant further validation.

In the following sections, the specific results obtained from addressing the three research issues and testing the five research hypotheses are provided. For the

reader's convenience, the research issues and research hypotheses are restated prior to discussing the research results.

Research Issue 1

Is there a reduction in replenishment spare parts prices when competition is introduced?

Research Hypothesis 1 results. Based on the research design outlined in Chapter 3, Research Hypothesis 1 was formulated to address Research Issue 1. Research Hypothesis 1 was formulated as follows:

H_0 : There is no reduction in unit price when weapon system replenishment spare parts, which previously were purchased on a sole source basis, are subsequently competitively purchased.

H_a : There is a reduction in unit price when weapon system replenishment spare parts, which previously were purchased on a sole source basis, are subsequently competitively purchased.

Research Hypothesis 1 was tested using four different sets of pricing data, all of which were initially converted to 1980 constant year dollars. The four data sets, summarized in Appendix A, consisted of price changes computed during:

1. comparison of the last sole source purchase prices to the first competitive purchase prices for the thirty-six line items;

2. comparison of the average sole source purchase prices to the average competitive purchase prices for the thirty-six line items;

3. comparison of the average sole source purchase prices to the average competitive purchase prices for twenty-nine of the thirty-six line items. Seven of the thirty-six line items were omitted from this comparison because the price changes, which resulted when competition was introduced into the acquisition process, were greater than a 50 percent increase or decrease. The seven items were omitted after discussions with ALC procurement personnel indicated that factors other than the three measured in this research study could significantly influence prices (e.g., retooling costs, increased cost of scarce metals, vendor buy-ins, sale of excess stock, etc.); and

4. comparison of the estimated sole source purchase prices to the first competitive purchase prices for fifteen of the thirty-six line items. The regression models for these fifteen items were judged to be valid and useful to predict sole source prices. The details and results of the regression modeling are provided in the next section. Comparisons of the computed price changes for these four data sets are provided in Appendix B.

The Statistical Package for the Social Sciences (SPSS) was used to compute the mean (average) price change (\bar{X}) and standard deviation ($\sigma_{\bar{X}}$) for each data set. Using

the computed data, the four tests of Research Hypothesis 1 were performed. Tables 7 and 8 summarize the elements of the large and small sample hypotheses tests. Table 7 applies to the first two tests of Research Hypothesis 1, while Table 8 applies to the third and fourth tests of Research Hypothesis 1.

The first test of Research Hypothesis 1 involved comparing the last sole source purchase prices to the first competitive purchase prices. The computed mean price change was a 16.9 percent increase in price (see Appendix B, Test 1). The SPSS computed mean price change and standard deviation were used to calculate the test statistic, specified in Table 7. The result was:

$$Z = \frac{\bar{X}}{\sigma/\sqrt{n}} = \frac{.169}{.547/\sqrt{36}} = \underline{\underline{1.854}}$$

Since the calculated Z statistic (1.854) was greater than - 1.645 (the critical value), H_0 was not rejected. The mean price change was a 16.9 percent price increase. Thus, the evidence did not support a conclusion that the introduction of competition into the weapon system replenishment spare parts acquisition process decreases prices. The initial tests results tend to contradict the general consensus of competition theory and past research studies which found that competition results in lower prices (18:p.15-16). The 95 percent confidence interval for the mean price change suggested that when competition was introduced into the

Table 7
Elements of Large Sample Hypothesis Test

$$H_0: \mu \geq 0$$

$$H_a: \mu < 0$$

$$\text{Test Statistic} \quad Z = \frac{\bar{X} - \mu}{\sigma_{\bar{X}}} = \frac{\bar{X} - 0}{\sigma/\sqrt{n}}$$

$$\text{Rejection Region} \quad Z < -1.645^*$$

* = significance level .05, n = 36 (21:636)
used for first and second tests of Research
Hypothesis 1

\bar{X} = sample mean

μ = specified population mean

$\sigma_{\bar{X}}$ = sampling distribution standard deviation
= σ/\sqrt{n}

n = sample size

Table 8
Elements of Small Sample Hypothesis Test

$$H_0: \mu \geq 0$$

$$H_a: \mu < 0$$

$$\text{Test Statistic} \quad t = \frac{\bar{X} - \mu}{s/\sqrt{n}} = \frac{\bar{X} - 0}{s/\sqrt{n}}$$

$$\text{Rejection Region} \quad t < t_{.05, n-1} = -1.761^*$$

$$t < t_{.05, n-1} = -1.701^{**}$$

* = significance level .05, n = 15 (21:637)
used for 4th test of Research Hypothesis 1

** = significance level .05, n = 29 (21:637)
used for 3rd test of Research Hypothesis 1

\bar{X} = sample mean

μ = specified population mean

s = sample standard deviation

n = sample size

spare parts acquisition process, 95 percent of the time mean price changes would occur in the range of a 1.6 percent decrease to a 35.4 percent increase, provided the sample of thirty-six items was representative of the entire population under consideration.

In the second test of Research Hypothesis 1, the averages of the sole source purchase prices and the averages of the competitive purchase prices were compared. The computed mean price change was an increase in price of 3.7 percent (See Appendix B, Test 2). The test statistic, specified in Table 7, was calculated using the SPSS computed mean price change and standard deviation. The resulting test statistic was as follows:

$$Z = \frac{\bar{X}}{\sigma/\sqrt{n}} = \frac{.037}{.474/\sqrt{36}} = .468$$

Since the calculated Z statistic (.468) was greater than - 1.645, H_0 was not rejected. Thus, as in the first statistical test, the results of the second test of Research Hypothesis 1 were not supportive of a conclusion that the introduction of competition results in lower spare parts prices. Provided the sample was representative of the population of replenishment spare parts, 95 percent of the time, mean price changes should range from a 12.3 percent decrease to a 19.8 percent increase when competition is introduced into the spare parts acquisition process.

The third test of Research Hypothesis 1 involved using the same data used in the second test, but after deleting from the research sample the seven line items with price changes greater than plus or minus 50 percent. The SPSS program computed a mean price change that represented a 2 percent price increase (See Appendix B, Test 3). The test statistic, specified in Table 8, was calculated using the SPSS computed mean price change and standard deviation. The resulting test statistic was as follows:

$$t = \frac{\bar{X}}{s/\sqrt{n}} = \frac{.02}{.28/\sqrt{29}} = .385$$

Since the calculated t statistic (.385) was greater than - 1.701 (the critical value), H_0 was not rejected. As in the two previous tests of Research Hypothesis 1, the conclusion was reached that the introduction of competition does not necessarily lower spare parts prices. The resulting 95 percent confidence interval for mean price changes indicated that price changes should range between a 8.7 percent decrease to a 12.7 percent increase when competition was introduced into the spare parts acquisition process, provided the sample was representative of the population of replenishment spare parts.

The fourth test of Research Hypothesis 1 involved comparing the first competitive purchase prices to estimated sole source purchase prices for the applicable spare part and competitive order quantity. The data set included only

those fifteen line items with regression models judged to be valid during the testing of Research Hypothesis 2 (See Appendix C, footnote 4). The computed mean price for the fourth test of Research Hypothesis 1 was a 6.4 percent price decrease (See Appendix B, Test 4). The test statistic, specified in Table 8, was calculated using the SPSS computed mean price change and standard deviation. The calculated test statistic for the fourth test of Research Hypothesis 1 was as follows:

$$t = \frac{\bar{X}}{s/\sqrt{n}} = \frac{-.064}{.531/\sqrt{15}} = -.467$$

Since the calculated t statistic (- .467) was greater than - 1.761, H_0 was not rejected. As in the three previous tests of Research Hypothesis 1, the evidence did not support a conclusion that introducing competition into the spare parts acquisition process results in lower prices. The 95 percent confidence interval for mean price changes indicated that if the sample was representative of the population, price changes would range between a 1.6 percent decrease to a 35.4 percent increase when competition was introduced into the spare parts acquisition process. However, prior to reaching any final conclusions regarding the effect of competition on spare parts prices, more empirical research will be needed.

Research Issue 2

Can a portion of any price change be attributed to the effects of competition?

Research Hypothesis 2 results. Based on the research design outlined in Chapter 3, Research Hypotheses 2 and 3 were formulated to address Research Issue 2. Research Hypothesis 2 was formulated as follows:

H_0 : A portion of the change in unit price, which results when competition is introduced into the weapon system replenishment spare parts acquisition process, cannot be attributed to the effects of competition.

H_a : A portion of the change in unit price, which results when competition is introduced into the weapon system replenishment spare parts acquisition process, can be attributed to the effects of competition.

To accomplish the testing of Research Hypothesis 2, the procurement data for each of the thirty-six line items were fit to separate least squares regression lines. A SPSS stepwise regression procedure was used to accomplish the regression analysis.

As previously stated in Chapter 3, a linear approximation model was used to measure the effects of order quantity and competition (i.e., procurement method) on prices. The multiple regression equation took the form

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + e.$$

In this multiple regression model, Y represented the unit price of an item. The variable X_1 was equal to the order quantity of the individual procurement actions. The

variable X_2 , which represented the procurement method, was defined as a dummy variable which took the value "0" if the purchase was competitive or "1" if the purchase was sole source. The variable X_3 represented the interaction between order quantity and procurement method. The testing of the variable X_3 was the subject of Research Hypothesis 3 and is discussed in the next section of this chapter.

To evaluate the effects of competition on price, the thirty-six regression models and coefficients of the variables X_1 and X_2 were evaluated. The student's t test was used to determine if the variables, X_1 and X_2 , contributed information toward the prediction of replenishment spare parts prices. Table 9 summarizes the elements of the test of each regression model's individual parameter coefficients.

Rejection of the null hypothesis ($B_i = \emptyset$) led to the conclusion that B_i , in the regression model, made an important contribution toward the prediction of price. For regression models in which the null hypothesis was not rejected, a conclusion about the contribution of B_i toward the prediction of replenishment spare parts prices was not reached.

Generally, tests results indicated that the effects of order quantity and procurement method on price were extremely variable (refer to Appendix C). The effects of procurement method on spare parts prices are summarized after a brief discussion of the effects of order quantity on replenishment spare parts prices.

Table 9
Elements of Student's t Test

$$H_0: B_i = \emptyset$$

$$H_a: B_i \neq \emptyset$$

$$\text{Test Statistic} \quad t = \frac{\hat{B}_i}{s_{\hat{B}_i}}$$

$$\begin{aligned} \text{Rejection Region} \quad t &< -t_{.025, n - (k + 1)} \text{ or} \\ t &> t_{.025, n - (k + 1)}^* \end{aligned}$$

* = significance level .05 for two tailed test is .025 (21:637) used for tests of Research Hypotheses 2 and 3

\hat{B}_i = estimated coefficients resulting from multiple regression modeling

$s_{\hat{B}_i}$ = estimated standard deviation for model coefficients

n = number of observations (i.e., number of procurement actions for the particular item)

k = number of independent variables in the model

Order quantity had a significant influence on price for five of the thirty-six line items (i.e., H_0 was rejected). In four of the five instances, unit prices tended to decrease as the order quantity increased.

The test results indicated that order quantity did not affect the unit price of most line items. However, when order quantity did have an effect on price, larger order quantities usually resulted in lower unit prices.

The effect of competition on price was also highly variable. The procurement method, variable X_2 , had a significant influence on price for eighteen of the thirty-six line items (i.e., H_0 was rejected). However, in only eight of the eighteen instances did the effect of competition tend to lower prices. For ten of the eighteen items, the effect of competition tended to increase prices.

The test results indicated that the effect of competition in the spare parts acquisition process did not always result in lower prices. In fact, more instances of price increases occurred than did instances of price decreases when competition was introduced into the replenishment spare parts acquisition process. The research results did not support the generally accepted principle that competition results in lower prices.

A secondary purpose for fitting a least squares regression line to the spare parts procurement data was to predict a sole source purchase price for comparison with

the first competitive purchase of an item (Test 4 of Research Hypothesis 1). Prior to using a regression model for price prediction, the complete regression models were evaluated. To evaluate the overall utility and predictive ability of the complete regression models, the coefficients of multiple determination were evaluated, and global F tests were accomplished for each one of the thirty-six multiple regression models. Table 10 highlights the elements of the global F test.

Rejection of the null hypothesis ($B_1 = B_2 = B_3 = \emptyset$) indicated that at least one of the independent variables was nonzero. Thus, the particular regression model was considered useful for predicting prices. Appendix C provides the R^2 values and the results of the global F tests for each one of the regression models representing the thirty-six line items.

After completing the global F tests, twenty of the thirty-six regression models were considered useful (i.e., H_0 was rejected). The R^2 values for these twenty regression models ranged from .9993 to .4566. Since the R^2 values measured how well the models fit the data, the author considered regression models with an R^2 less than .8 to be of questionable utility for the purpose of predicting prices. Thus, five of the twenty regression models, which had R^2 values of less than .8, were not used for predicting sole source prices.

Table 10
Elements of Global F Test

$H_0: B_1 = B_2 = B_i = \emptyset$

$H_a: \text{At least one } B_i \text{ is nonzero}$

Test Statistic $F = \frac{R^2}{(1 - R^2)/[n - (k + 1)]}$

Rejection Region $F > F_{.05, k, n - (k + 1)}^*$

* = significance level .05 (21:638)

R^2 = coefficient of multiple determination

k = number of independent variables in model

n = number of observations (i.e., number of procurement actions for the particular item)

The regression models for the other fifteen line items were used to predict sole source purchase prices for comparison with the first competitive purchase prices. The results of these computations were previously discussed in this chapter (see Test 4 of Research Hypothesis 1). The empirical evidence did not support a conclusion that the effect of introducing competition into the replenishment spare parts acquisition process was lower prices.

Research Hypothesis 3 results. Based on the research design outlined in Chapter 3, Research Hypotheses 2 and 3 were formulated to address Research Issue 2. Research Hypothesis 3 was formulated as follows:

H_0 : The effect of order quantity on price is the same for both competitive and sole source weapon system replenishment spare parts purchases (i.e., the unit price per order quantity is the same regardless of the procurement method.)

H_a : The effect of order quantity on price differs for competitive and sole source weapon system replenishment spare parts purchases (i.e., the unit price per order quantity differs for each procurement method.)

To test Research Hypothesis 3, the coefficients of the interaction variable, X_3 , were evaluated using the criteria previously specified in Table 9. The test was the same test which was used to evaluate the coefficients of the variables, X_1 and X_2 (Research Hypothesis 2).

The variable X_3 was previously defined as the interaction between order quantity and procurement method (i.e., cross product of X_1 and X_2). If X_3 was judged to be significant (i.e., H_0 was rejected), the conclusion was made that the unit price per order quantity differed for sole source and competitive purchases of the particular line items. The results of testing the significance of the coefficient of X_3 in the thirty-six regression models are highlighted in Appendix C.

The unit price per order quantity for sole source and competitive purchases differed for six of the thirty-six line items (i.e., H_0 was rejected). For five of the six line items, sole source unit prices per order quantity decreased faster than competitive unit prices per order quantity. Thus, if large purchases were contemplated, there may be potential for greater savings by remaining in the sole source mode of purchasing rather than introducing competition for those items.

In summary, the unit price per order quantity for sole source and competitive purchases differed for only a few of the line items. Thus, the empirical evidence did not support a conclusion that the interaction between order quantity and procurement method significantly influenced prices (i.e., the slopes of the competitive and sole source regression lines were similar.)

Research Issue 3

Is the magnitude of any price change influenced by certain factors (i.e., type of item or number of solicitations)?

Research Hypothesis 4 results. Based on the research design outlined in Chapter 3, Research Hypotheses 4 and 5 were formulated to address Research Issue 3. Research Hypothesis 4 was formulated as follows:

H_0 : The change in unit price, which results when competition is introduced into the acquisition process, is the same for all types (i.e., commodity groups) of weapon system replenishment spare parts.

H_a : The change in unit price, which results when competition is introduced into the acquisition process, differs for at least two types (i.e., commodity groups) of weapon system replenishment spare parts.

Research Hypothesis 4 was tested by categorizing the thirty-six line items by commodity group (see Figure 5), computing a mean (average) price change for each commodity group, and performing an analysis of variance (ANOVA) test on the categorized data. The ANOVA test was accomplished using average sole source and average competitive purchase prices (see Tests 2 and 3 of Research Hypothesis 1.) The elements for performing the analysis of variance test are summarized in Table 11.

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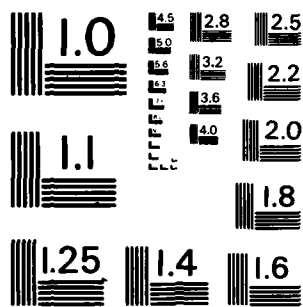
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Table 11
Elements of Analysis of Variance Test

$H_0: \mu_1 = \mu_2 = \dots = \mu_k$ $H_a: \text{At least two group means differ}$

Test Statistic $F = \frac{MST}{MSE}$

Rejection Region $F > F_{.05, (k - 1), (n - k)}^*$

* = significance level .05 (21:638)

μ = population mean (i.e., average group price change)

MST = mean square for treatments (groups) (measure of variability between groups)

MSE = mean square for error (measure of variability within groups)

k = number of treatments (groups)

n = number of observations

The results from categorizing the thirty-six items into the commodity groups, previously specified in Figure 5, are provided in Table 12.

Table 12
Categorization of Thirty-Six Line
Items By Commodity Group

No. of Items	Commodity Groups										Total Items
	1	2	3	4	5	6	7	8	9	10	
	3	9	2	0	10	0	1	2	3	6	36

To increase the accuracy of the ANOVA test, only commodity groups with three or more line items were compared.

The SPSS program was used to compute the applicable statistics and F value. Since five commodity groups ($k = 5$) were compared, and the five commodity groups included a total of thirty-one items ($n = 31$), the rejection region was determined to be $F > F_{.05,4,26} = 2.74$ (21:638).

The SPSS computed F value (2.42) was less than the critical F value (2.74) (i.e., H_0 was not rejected). Thus, the test result indicated that price changes among various commodity groups were not significantly different. However, price changes for a larger sample of items should be analyzed before reaching the final conclusion that price changes, which result when competition is introduced into the replenishment spare parts acquisition process, among various commodity groups do not differ.

After removing the seven line items, which experienced more than a 50 percent increase or decrease in price, from the research sample (see Appendix B, Test 3), another ANOVA test was performed. As in the previous ANOVA test, the SPSS computed F value (2.04) was less than the critical F value ($F_{.05,3,21} = 3.07$) (i.e., H_0 was not rejected). Thus, prior to reaching any final conclusion regarding the differences in price changes among various commodity groups, additional sample data should be analyzed.

Research Hypothesis 5 results. Based on the research design outlined in Chapter 3, Research Hypotheses 4 and 5 were formulated to address Research Issue 3. Research Hypothesis 5 was formulated as follows:

H_0 : The change in unit price, which results when competition is introduced into the weapon system replenishment spare parts acquisition process, remains the same as the number of solicitations changes.

H_a : The change in unit price, which results when competition is introduced into the weapon system replenishment spare parts acquisition process, differs as the number of solicitations changes.

The same technique (i.e., ANOVA) used to test the fourth research hypothesis was also used to test Research Hypothesis 5. After categorizing the thirty-six line items by average number of solicitations, a mean price change for each category of solicitations was computed, and an ANOVA

test was performed. The elements of the ANOVA test were previously summarized in Table 11.

As in the tests of Research Hypothesis 4, the average sole source and competitive purchase prices were used in the tests of Research Hypothesis 5. Prior to categorizing the thirty-six line items, the average number of solicitations for each line item was calculated (i.e., the total number of solicitations for the competitive procurement actions was divided by the number of competitive procurement actions.) The items were then categorized into three groups by the average number of solicitations for the competitive procurement actions. The three groups were: 1) two solicitations; 2) three or four solicitations; and 3) five or more solicitations. The results of categorizing the thirty-six line items by the average number of solicitations for the competitive procurement actions are provided in Table 13.

Table 13
Categorization of Thirty-Six Line Items By
Average Number of Solicitations

No. of Items	Average Number of Solicitations			Total
	2	3-4	≥ 5	
	13	12	11	36

The SPSS program was used to compute the applicable statistics. Since three groups ($k = 3$) were compared, and the total items in the groups was 36 ($n = 36$), the rejection region for the first test of Research Hypothesis 5 was determined to be $F > F_{.05,2,33} = 3.30$ (21:638).

The SPSS computed F value (.95) was less than the critical F value (3.30) (i.e., H_0 was not rejected). Thus, the empirical evidence suggested that price changes do not significantly differ as the number of solicitations change. However, price changes for a larger sample of items should be analyzed before reaching the final conclusion that price changes, which result when competition is introduced into the replenishment spare parts acquisition process, do not differ as the number of solicitations changes.

After removing the seven line items, which experienced more than a 50 percent increase or decrease in price, from the research sample (see Appendix B, Test 3), another ANOVA test was performed. As in the previous ANOVA test, the SPSS computed F value (1.27) was less than the critical F value ($F_{.05,2,26} = 2.37$) (i.e., H_0 was not rejected).

Thus, prior to reaching any final conclusion regarding the differences in price changes as the number of solicitations change, additional sample data should be analyzed.

Summary

Chapter 4 presented the research results obtained from applying the research methodology, described in Chapter

3. In this fourth chapter, the specific findings of the data analyses and tests of the five research hypotheses were highlighted and explained.

Generally, the research results are contrary to the results of previous empirical research and competition theory. The test results indicated that:

1. Introducing competition did not guarantee lower prices;
2. For many items, a portion of the change in price could be attributed to the effects of competition, but the effect of competition was as likely to raise prices as lower prices; and
3. Price changes were not influenced by a change in the number of solicitations and were similar among commodity groups.

In the final chapter, the research results, including the implications of the research findings and the author's conclusions are provided. The author's suggestions for future research are highlighted and are followed by some concluding observations.

Chapter 5

IMPLICATIONS, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

This final chapter provides a summary of the author's research project and conclusions. First, a summary of the background, objectives, and methodology of the research study is presented. The research summary is followed by the implications and conclusions that culminated from addressing three research issues and evaluating five research hypotheses. Following the discussion of the research implications and conclusions, recommendations for future research are provided. Finally, the author presents some concluding observations.

Summary of Background, Objectives, and Methodology

The Defense Acquisition Regulation (DAR) dictates that competition is the "law of the land" in Department of Defense (DoD) procurement (7:Para.1-302.2). The need for competition in the Government's acquisition of materials and services is continually stressed by Congress, taxpayers, and Government officials. Yet, the Government has no specific guidelines or firm basis for deciding when to introduce competition or even if competition should be introduced into the acquisition process. Buyers are

continually faced with uncertainty in deciding when and what to compete.

The overall objective of this research project was to determine the effect of competition on the prices of weapon system replenishment spare parts. Specifically, three research issues were addressed in the study. The three research issues were:

1. Is there a reduction in replenishment spare parts prices when competition is introduced?
2. Can a portion of any price change be attributed to the effects of competition?
3. Is the magnitude of any price change influenced by certain specified factors (i.e., type of item or number of solicitations)?

The data used to address the three research issues were obtained from procurement history files maintained by the Air Force Logistics Command (AFLC). From the five AFLC Air Logistics Centers' current procurement history files (i.e., approximately four years of data), thirty-six weapon system replenishment spare parts, which initially were purchased on a sole source basis at least three consecutive times and subsequently were competitively purchased at least three consecutive times, were selected for analysis. Multiple regression analysis and parametric statistical tests were used to analyze the procurement history data. In this research project, price changes were attributed to three factors: inflation, order quantity, and competition.

Five research hypotheses were formulated and tested to address the three research issues. The following sections highlight the implications from addressing the three issues and the author's conclusions related to the specific research findings.

Implications and Conclusions

Research Issues. This research project succeeded in providing insight into the three research issues. Although the author's research results should be considered preliminary and warrant further validation, the findings tend to support conclusions that:

1. The introduction of competition into the replenishment spare parts acquisition process does not guarantee lower prices;
2. For many items, competition accounts for a portion of the price change, but the effect of competition is just as likely to result in price increases as price decreases; and
3. Price changes are similar among commodity groups and are not influenced by the number of solicitations.

Specific implications and conclusions concerning the five research hypotheses are provided in the following sections.

Research Hypothesis 1. The first research hypothesis, tested in this research project, was formulated as follows:

H_0 : There is no reduction in unit price when weapon system replenishment spare parts, which previously were purchased on a sole source basis, are subsequently competitively purchased.

H_a : There is a reduction in unit price when weapon system replenishment spare parts, which previously were purchased on a sole source basis, are subsequently competitively purchased.

Since H_0 was not rejected in any of four separate tests of Research Hypothesis 1, the empirical evidence did not support a conclusion that prices decrease when competition is introduced into the weapon system replenishment spare parts acquisition process. Further, there is an indication that prices of many spare parts actually increase when competition is introduced into the spare parts acquisition process. In three of the four tests of Research Hypothesis 1 the mean price change for spare parts was an increase in price. The empirical evidence indicated that, generally, prices were just as likely to increase as to decrease upon introducing competition.

The statistical test results indicated that the introduction of competition did not guarantee lower prices. Thus, the author concluded that either: 1) the savings which resulted from introducing competition into the spare parts acquisition process were significantly less than generally anticipated; or 2) other factors, not specifically

identified in this study, tended to offset the price reductions which the author attributed to the effects of competition. Additional empirical research will be necessary prior to making any final conclusions regarding spare parts price changes upon introducing competition into the acquisition process.

Research Hypothesis 2. Research Hypothesis 2 was formulated as follows:

H_0 : A portion of the change in unit price, which results when competition is introduced into the weapon system replenishment spare parts acquisition process, cannot be attributed to the effects of competition.

H_a : A portion of the change in unit price, which results when competition is introduced into the weapon system replenishment spare parts acquisition process, can be attributed to the effects of competition.

Since H_0 was rejected for eighteen of the thirty-six spare parts, the author concluded that for those eighteen line items, portions of the price changes were attributable to the effects of competition. However, the effects of competition lowered prices in only eight of the eighteen instances. Thus, for twenty-eight of the thirty-six line items, competition had either an increasing influence or insignificant influence on spare parts prices.

The statistical test results indicated that competition may not be cost beneficial for all spare parts

purchases. Since one ultimate goal of Government procurement is to efficiently use available financial resources, the research results suggest that not all spare parts should be competed. Thus, the author contends that blanket application of the DAR requirement to secure maximum competition is inappropriate for all spare parts purchases. Prior to making procurement method decisions, buyers need to understand and objectively evaluate the other factors which could influence prices.

Generally, the statistical results are contrary to the results of previous empirical studies (24:82; 26:9) and competition theory (10:2). Thus, additional empirical research is needed to determine the actual benefits of competition in spare parts procurement. In addition, more contracting guidance is needed to identify the specific conditions under which competition is likely to produce cost savings.

Research Hypothesis 3. Research Hypothesis 3 was formulated as follows:

H_0 : The effect of order quantity on price is the same for both competitive and sole source purchases of weapon system replenishment spare parts (i.e., the unit price per order quantity is the same regardless of the procurement method.)

H_a : The effect of order quantity on price differs for competitive and sole source purchases of weapon system

replenishment spare parts (i.e., the unit price per order quantity differs for each procurement method.)

Since H_0 was rejected for only five of thirty-six line items, the author concluded that, in general, order quantity affected price the same regardless of the procurement method. However, when unit prices per order quantity differed, sole source unit prices decreased faster than the competitive unit prices for the same item and order quantity.

Since prices per order quantity are similar regardless of the procurement method, the author suggests that, for small dollar items, the size of the order need not be a consideration in the procurement method decision because there would be little potential for cost savings. However, for large dollar items, there may be benefits to examining the sole source and competitive unit price per order quantity relationships for similar items, because for those large dollar items there is potential for greater savings than for small dollar items. If a significant difference in the sole source and competitive unit prices per order quantity exists, the author contends that the order quantity should be a consideration in the buyer's procurement method decision.

Research Hypothesis 4. Research Hypothesis 4 was formulated as follows:

H_0 : The change in unit price, which results when competition is introduced into the acquisition process, is the same for all types (i.e., commodity groups) of weapon system replenishment spare parts.

H_a : The change in unit price which results when competition is introduced into the acquisition process, differs for at least two types (i.e., commodity groups) of weapon system replenishment spare parts.

No significant difference in mean price changes among six different commodity groups was noted (i.e., H_0 was not rejected). Thus, the empirical evidence did not support a conclusion that there is potential for greater savings in particular commodity groups (i.e., prices did not differ among groups). The empirical evidence suggests that price changes, which result when competition is introduced into the weapon system replenishment spare parts acquisition process, are not significantly different among the various commodity groups. However, additional data should be gathered and analyzed prior to reaching any final conclusions concerning the effects of competition on spare parts prices among the various commodity groups.

Research Hypothesis 5. Research Hypothesis 5 was formulated as follows:

H_0 : The change in unit price, which results when competition is introduced into the weapon system replenishment spare parts acquisition process, remains the same as

the number of solicitations changes.

H_a : The change in unit price, which results when competition is introduced into the weapon system replenishment spare parts acquisition process, differs as the number of solicitations changes.

The empirical evidence did not support a conclusion that price changes differed as the number of solicitations changes (i.e., H_0 was not rejected). Greater price reductions did not occur as the number of solicitations increased. Generally, price changes were similar when either a small or large number of bids was solicited from business firms. The empirical evidence suggests that price changes, which result when competition is introduced into the weapon system replenishment spare parts acquisition process, are similar regardless of the degree of potential available competition. Thus, incurring significant costs to create alternative sources of supply may not be warranted. However, additional data should be analyzed prior to reaching a final conclusion concerning the influence of the number of solicitations on price.

Recommendations for Future Research

In performing this research project, several areas warranting further study and analysis were identified. In this section, the author highlights five of those areas for future research.

Replication of this study. The results of this study were contrary to both competition theory and the results obtained

from previous empirical research. In addition, the computed price changes for the sample of thirty-six weapon system replenishment spare parts were highly variable. Thus, the author suggests that this study be replicated with a different sample of weapon system replenishment spare parts. Replication of this study, accomplished with current data, would serve to further validate the conclusions of this researcher's study.

Replication of study with methodology modifications. The author suggests this study be replicated after making some minor revisions to the research methodology. The revisions include: 1) changing the sample selection criteria to allow analysis of data for spare parts that have nonconsecutive sole source and competitive purchases; and 2) obtaining complete historical procurement data for the selected items so that a learning curve relationship can be incorporated into the sole source price predictions. These slight research methodology modifications would permit analysis of a larger sample of data, allow for more accurate predictions of sole source prices, and provide more accurate estimations and meaningful comparisons of price changes.

Identification of other price influencing factors. During the course of this research project, the author identified several factors, other than the three accounted for in this study, which could significantly influence prices of spare parts. Many of the factors could offset the portion of any

price reduction attributed to the effect of introducing competition. Further research should be performed to identify, through discussions with buyers and competing firms, other factors which influence prices. One such factor to investigate in future research is the dollar value of the item. For example, a comparative study to determine whether competition has a greater influence on higher priced items than on lower priced items should be performed.

Analysis of offsetting costs. Since the results of this research project suggested that the benefits of introducing competition into the weapon system replenishment spare parts acquisition process were considerably less than generally anticipated, a small increase in offsetting costs (i.e., procurement data costs, decrease in quality or reliability, bid package preparation costs, etc.) could have resulted in an overall increase in total procurement costs. A follow-on research study is needed to quantify the various costs associated with both sole source and competitive purchases of replenishment spare parts. The identified costs could then be included as a consideration in the procurement method decision.

The role of competition after initial introduction. The author also recommends that a study be undertaken to determine why once competition has been introduced for a particular spare part, all subsequent purchases of that spare part are

not made using competition. In this research project, the author noted that for many items purchases randomly and frequently switched back and forth between sole source and competition (i.e., during FY 78-82, only the thirty-six items analyzed in this study were always competitively purchased after competition was introduced.) Since maximum competition remains the policy in DoD procurement, these replenishment spare parts represent a significant potential source for increasing competitive purchases.

Concluding Observations

As previously stated, the overall findings of this research project, generally, do not support the results of previous empirical research and are contradictory to accepted competition theory. Thus, in many ways, this research has raised more questions about the role of competition in spare parts acquisition. One such question concerns the role of competition in major systems and components procurement versus spare parts procurement. Since the majority of previous empirical studies dealt with the acquisition of major systems and components rather than spare parts, the results of this research project led the author to question whether the benefits of competition are as great in spare parts procurement as in major system acquisition.

The empirical results of this study indicate that, in general, spare parts procurement in the DoD marketplace may not be conducive to competition. Although in certain

instances introducing competition resulted in lower prices, competition did not always guarantee lower prices. The research results suggested that prices are just as likely to increase as to decrease when competition is introduced into the weapon system replenishment spare parts acquisition process. The results of this research project supported a conclusion that, in many instances, the goals of minimizing costs and maximizing competition may be conflicting goals. However, the results of two previous empirical research studies, which estimated average price reductions for spare parts of 12.4 percent (24:82) and 24.3 percent (26:9) when competition was introduced into the spare parts acquisition process, tend to support the opposite conclusion that competition results in lower prices.

Thus, much research remains to be done to determine the impact of competition on weapon system replenishment spare parts prices. The author hopes that this research project will serve as a catalyst for further study of the benefits of competition in spare parts acquisition.

APPENDIX A
LIST OF SAMPLE DATA

Item ID ¹	National Stock Number	Actual Prices*		Estimated*		Average Prices*		Commodity Group	Average Number of Solicitations
		Last Purchase	First Competitive Purchase	Sole Source Price To Compare With First Competitive Price	Sole Source Price	Sole Source Competitive	Competitive		
WR1	1095 00 450 8483	289.06	99.92	280.01	278.51	114.08	7	10	
WR2	5841 00 050 1533	790.00	893.00	-	917.08	731.74	9	5	
SC1	4710 01 034 4799PT	236.59	294.89	238.32	237.40	322.16	5	2	
SC2	5840 00 396 1193	2321.04	1614.47	1960.79	2344.56	1634.23	9	6	
OK1	1650 00 204 1703	841.67	845.00	-	1073.78	980.96	10	6	
OK2	1650 01 047 3033	2282.46	2386.39	-	2037.07	2315.66	10	10	
OK3	2840 00 568 1078RU	2038.94	2809.64	-	2051.31	2584.62	2	3	
OK4	5320 01 003 1333PQ	1.82	2.75	-	1.52	2.27	5	3	
OK5	6605 00 815 1903	169.78	161.15	-	129.24	137.55	3	4	
OK6	6610 00 441 0523	7284.13	4191.99	10365.49	8312.47	3961.18	3	3	
HL1	1377 00 125 0074	86.60	55.18	-	92.86	68.98	8	2	
HL2	1377 00 412 3205	116.59	45.00	122.00	119.50	33.88	8	2	

* Prices stated in 1980 constant year dollars.

¹WR = Warner Robins ALC, SC = Sacramento ALC, OK = Oklahoma City ALC, HL = Ogden ALC.

- Estimated sole source price not computed due to questionable predictive ability of regression models (see Research Hypothesis 2 and Test 4 of Research Hypothesis 1).

Item ID ¹	National Stock Number	Actual Prices*		Estimated Sole Source Price To Compare With First Competitive Price*	Average Prices*			Average Number of Solicitations
		Last Sole Source Purchase	First Competitive Purchase		Sole Source	Competitive	Group	
HL3	1560 00 137 1377BF	12.80	3.93	13.43	12.80	3.40	1	2
HL4	1560 00 928 0733BF	136.96	282.41	-	112.08	130.78	1	32
HL5	1560 00 980 0560BF	137.89	231.89	-	145.01	189.88	1	30
HL6	1620 00 677 6681	4699.44	3720.00	-	3694.68	3415.16	10	2
HL7	1650 00 872 0322BF	256.40	237.22	-	349.20	241.90	10	2
HL8	5970 00 350 1184BF	23.52	10.73	24.17	24.05	12.40	9	24
SN1	1690 00 226 0954XJ	105.83	106.28	-	94.60	97.25	10	2
SN2	2840 00 343 7820PT	33.56	22.55	22.96	31.13	21.91	2	4
SN3	2840 00 343 8259PT	310.64	850.99	-	338.94	739.15	2	2
SN4	2840 00 394 4947PT	324.33	347.49	-	665.70	470.59	2	4
SN5	2840 01 063 6533PT	394.61	671.95	445.45	410.19	684.91	2	6
SN6	2840 01 063 6534PT	193.60	388.58	238.27	224.52	556.96	2	4

* Prices stated in 1980 constant year dollars.

¹ HL = Ogden ALC, SN = San Antonio ALC.

- Estimated sole source price not computed due to questionable predictive ability of regression models (see Research Hypothesis 2 and Test 4 of Research Hypothesis 1).

Item ID ¹	National Stock Number	Actual Prices*		Estimated Sole Source Price To Compare With First Competitive Price	Average Prices*		Commodity Group	Average Number of Solicitations
		Sole Source Purchase	First Competitive Purchase		Sole Source	Competitive		
SN7 2840 01 063 6544PT		9.86	11.23	9.15	9.17	13.40	2	7
SN8 2840 01 068 6462PT		34.86	75.50	-	39.31	54.39	2	4
SN9 2915 01 084 2636PT		434.00	416.66	253.58	443.00	449.54	2	2
SN10 5120 00 473 5379RX		785.88	985.44	758.64	773.29	891.79	10	5
SN11 5305 00 367 8768PT		1.73	3.20	-	1.89	2.60	5	3
SN12 5306 00 006 5194XJ		12.85	14.77	47.15	18.89	12.60	5	3
SN13 5306 00 425 8426PT		14.73	18.13	-	19.01	17.46	2	5
SN14 5306 00 481 2159PT		8.25	13.06	8.64	8.14	10.52	5	3
SN15 5330 00 365 2978PT		2.06	1.85	-	1.73	1.18	5	2
SN16 5330 01 010 3372		14.72	16.75	-	16.58	14.06	5	2
SN17 5340 01 057 5502PT		.75	.78	-	.80	1.01	5	3
SN18 5340 01 068 8137PT		74.99	101.85	-	88.86	89.80	5	2

* Prices stated in 1980 constant year dollars.

¹ SN = San Antonio ALC.

- Estimated sole source price not computed due to questionable predictive ability of regression models (see Research Hypothesis 2 and Test 4 of Research Hypothesis 1).

APPENDIX B

COMPARISON OF PERCENTAGE CHANGE IN UNIT
PRICES APPLICABLE TO FOUR TESTS
OF RESEARCH HYPOTHESIS 1

Item ID ¹	Test 1		Tests 2/3		Test 4	
	Last Sole Source		Average Sole Source		Estimated Sole Source	
	vs. First Competitive**		vs. Average Competitive**		vs. First Competitive**	
WR1	- .654		- .590*		- .643	
WR2	.130		- .202		-	
SC1	.246		.357		.235	
SC2	- .304		- .303		- .177	
OK1	.004		- .086		-	
OK2	.046		.137		-	
OK3	.378		.260		-	
OK4	.509		.490		-	
OK5	- .051		.064		-	
OK6	- .425		- .523*		- .596	
HL1	- .363		- .257		-	
HL2	- .614		- .717*		- .631	
HL3	- .693		- .734*		- .707	
HL4	1.062		.167		-	
HL5	.682		.309		-	
HL6	- .208		- .076		-	
HL7	- .075		- .307		-	
HL8	- .544		- .484		- .556	

* Item deleted from sample prior to accomplishing third test of Research Hypothesis 1
(Change < - .5 or > .5)

** Negative number indicates percentage decrease in unit price.

¹WR = Warner Robins ALC, SC = Sacramento ALC, OK = Oklahoma City ALC, HL = Ogden ALC.

- Estimated sole source price not computed due to questionable predictive ability of regression models (see Research Hypothesis 2).

Item ID ¹	Test 1		Tests 2/3*		Test 4	
	Last Sole Source		Average Sole Source		Estimated Sole Source	
	vs. First Competitive	**	vs. Average Competitive	**	vs. First Competitive	**
SN1	.004		.028		-	
SN2	-.328		-.296		-.018	
SN3	1.739		1.181*		-	
SN4	.071		-.293			
SN5	.703		.670*		.509	
SN6	1.007		1.481*		.631	
SN7	.139		.461		.227	
SN8	1.166		.381		-	
SN9	-.040		.015		.643	
SN10	.254		.153		.299	
SN11	.850		.376		-	
SN12	.149		.333		-.687	
SN13	.231		-.081		-	
SN14	.583		.293		.512	
SN15	.103		.316		-	
SN16	.138		-.152		-	
SN17	.036		.262		-	
SN18	.358		.011		-	
Mean (\bar{X})	.169		.037/.02*		-.064	

* Item deleted from sample prior to accomplishing third test of Research Hypothesis 1 (Change < -.5 or > .5).

** Negative number indicates percentage decrease in unit price.

¹ SN = San Antonio ALC.

- Estimated sole source price not computed due to questionable predictive ability of regression models (see Research Hypothesis 2).

APPENDIX C

RESULTS OF TESTING SIGNIFICANCE OF MULTIPLE
REGRESSION MODELS AND COEFFICIENTS
OF INDEPENDENT VARIABLES

Item ID ¹	R ²	Global F Test		Student's t Test			
		Rejection Region ²	Computed Value	B ₁		B ₂	
				Computed Value	Rejection Region ³	Computed Value	Computed Value
WR1	.9508 ⁴	F .05, 1, 5=6.61	96.64*	-	t .025, 5=2.57	9.83*	-
WR2	.7055	F .05, 3, 3=9.28	2.40	-	t .025, 3=3.18	- 1.32	2.05
SC1	.9943 ⁴	F .05, 3, 3=9.28	175.86*	6.52*	t .025, 3=3.18	- 8.60*	- 6.41*
SC2	.9655 ⁴	F .05, 2, 8=4.46	112.01*	-	t .025, 8=2.31	10.85*	- 2.32*
OK1	.1667	F .05, 1, 5=6.61	1.00	- 1.00	t .025, 5=2.57	-	-
OK2	.1128	F .05, 1, 9=5.12	1.14	-	t .025, 9=2.26	-	- 1.07
OK3	.7388	F .05, 2, 4=6.94	5.66	-	t .025, 4=2.78	- 3.27*	1.70
OK4	.7220	F .05, 2, 4=6.94	5.20	**	t .025, 4=2.78	**	**
OK5	.1489	F .05, 2, 27=3.35	2.36	- 1.95	t .025, 27=2.05	- 1.16	-
OK6	.9958 ⁴	F .05, 2, 7=4.74	822.94*	- 12.35*	t .025, 7=2.37	40.54*	-
HL1	.5363	F .05, 1, 28=4.20	28.72*	-	t .025, 28=2.05	5.36*	-
HL2	.9840 ⁴	F .05, 3, 24=3.01	493.42*	- 3.00*	t .025, 24=2.06	25.61*	1.31

* Significant at .05 level.

** Values too small to compute (i.e., less than .0005).

- Variable not included in model.

¹WR = Warner Robins ALC, SC = Sacramento ALC, OK = Oklahoma City ALC, HL = Ogden ALC.

²Refer to Table 9 (21:Table VI) Rejection region $F > F_{.05, k, n - (k+1)}$.

³Refer to Table 10 (21:Table V) Rejection region $t < - t_{.025, n - (k+1)}$ or $t > t_{.025, n - (k+1)}$.

⁴Item used in 4th test of Research Hypothesis 1.

Item ID ¹	R ²	Global F Test		Student's t Test		
		Rejection Region ²	Computed Value	B ₁		B ₃
				Computed Value	Computed Value	
HL3	.9993 ⁴	F .05, 2, 3=9.55	2167.70*		26.79*	-
HL4	.0161	F .05, 1, 11=4.84	.18	-	-	.423
HL5	.3397	F .05, 1, 8=5.32	4.12	-	2.03	-
HL6	.0844	F .05, 2, 23=3.42	2.21	-	1.49	-
HL7	.1658	F .05, 1, 5=6.61	.99	-	1.00	-
HL8	.8749 ⁴	F .05, 1, 6=5.99	41.97*	-	6.48*	-
SN1	.0641	F .05, 1, 11=4.84	.75	-	-	.865
SN2	.9532 ⁴	F .05, 3, 9=3.86	61.12*	**	12.02*	- 3.00*
SN3	.6999	F .05, 1, 6=5.99	13.93*	-	3.73*	-
SN4	.1231	F .05, 2, 13=3.81	.91	- 1.12	-	1.00
SN5	.8265 ⁴	F .05, 2, 12=3.89	28.58*	- 1.75	7.46*	-
SN6	.8180 ⁴	F .05, 1, 5=6.61	22.48*	-	4.74*	-

* Significant at .05 level.

** Values too small to compute (i.e., less than .0005).

- Variable not included in model.

¹ HL = Ogden ALC, SN = San Antonio ALC.

² Refer to Table 9 (21:Table VI) Rejection region $F > F_{.05, k, n - (k+1)}$.

³ Refer to Table 10 (21:Table V) Rejection region $t < -t_{.025, n - (k+1)}$ or $t > t_{.025, n - (k+1)}$.

⁴ Item used in 4th test of Research Hypothesis 1.

Item ID ¹	R ²	Global F Test Model		Student's t Test		
		Rejection Region ²	Computed Value	Rejection Region ³	B ₁ Computed Value	B ₂ Computed Value
SN7	.8398 ⁴	F .05, 2, 8=4.46	20.96*	t .025, 8=2.31	2.23	- 6.47*
SN8	.3413	F .05, 2, 12=3.89	3.11	t .025, 12=2.18	1.96	- 1.39
SN9	.9098 ⁴	F .05, 2, 3=9.55	15.13*	t .025, 3=3.18	- 4.92*	- 4.39*
SN10	.8672 ⁴	F .05, 2, 6=5.14	19.59*	t .025, 6=2.45	- 2.72*	- 6.23*
SN11	.3930	F .05, 1, 8=5.32	5.18	t .025, 8=2.31	-	- 2.28
SN12	.8113 ⁴	F .05, 2, 7=4.74	15.05*	t .025, 7=2.37	-	5.40*
SN13	.6584	F .05, 2, 6=5.14	5.78	t .025, 6=2.45	-	- 2.39
SN14	.9082 ⁴	F .05, 2, 7=4.74	34.61*	t .025, 7=2.37	**	- 8.29*
SN15	.4566	F .05, 1, 7=5.59	5.88*	t .025, 7=2.37	-	2.42*
SN16	.2019	F .05, 2, 4=6.94	.51	t .025, 4=2.78	- 1.00	-
SN17	.6674	F .05, 3, 8=4.07	5.35*	t .025, 8=2.31	**	.53
SN18	.1056	F .05, 1, 14=4.60	1.65	t .025, 14=2.15	- 1.29	-

* Significant at .05 level.

** Values too small to compute (i.e., less than .0005).

- Variable not included in model.

¹ SN = San Antonio AIC.

² Refer to Table 9 (21:Table VI) Rejection region $F > F_{.05, k, n - (k+1)}$.

³ Refer to Table 10 (21:Table V) Rejection region $t < -t_{.025, n - (k+1)}$ or $t > t_{.025, n - (k+1)}$.

⁴ Item used in 4th test of Research Hypothesis 1.

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